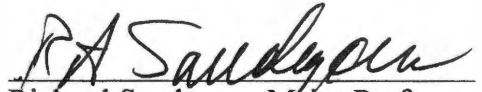
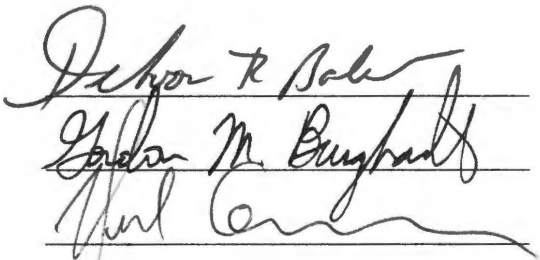


To the Graduate Council:

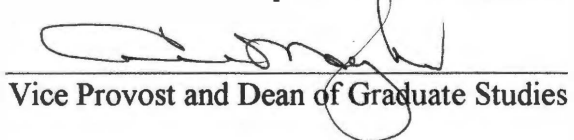
I am submitting herewith a dissertation written by Todd Joseph Smith entitled "Behavior Changes During Translocation of a Captive Troop of *Loxodonta Africana*." I have examined the final paper copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Psychology.


Richard Saudargas, Major Professor

We have read this dissertation
and recommend its acceptance:



Acceptance for the Council:


Vice Provost and Dean of Graduate Studies

Thesis
2003b
.S657

Behavior Changes During Translocation of a Captive Troop of *Loxodonta Africana*

**A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville**

**Todd Joseph Smith
December 2003**

ACKNOWLEDGEMENTS

I wish to thank all those who helped me complete my Doctor of Philosophy degree in psychology. I would like to thank Dr. Saudargas for his guidance and patience with my writing style. I would like to thank Dr. Burghardt for making me familiar with the principles of ethology and for sending me current news within the field. I would like to thank Dr. Greenburg for trying to convince me to go to Africa. I would also like to thank Dr. Baldwin for serving on my committee.

I would like to thank the following for assisting me with the observations and data entry: Nicole Perez, Pamela Carter, Amanda Harrell, Geoffrey Pettit, Cody Hanford, Brian Lamb, Ashley Thompson, Eric Phillips, Susan Zoesch, Nayoung Kim, Beau Bradley, Rebecca Davidso, Charles Galyon, Leslie McDaniel, Duree Snapp, Katherine Wargo, Alison Creel, David Yost, Andrea Wooward, Tiffany Taylor, and O' Brian Goodwin.

Finally, I would like to thank my wife Jennifer, whose support and encouragement made this work possible.

ABSTRACT

Translocation, the transfer of animals from one location to another, is an important and common aspect of captivity, although little scientific knowledge has been gained from the process. The purpose of this study was to add to the scientific literature on captive large mammal translocation through behavioral observation of a captive group of African elephants, *Loxodonta africana*.

Knoxville Zoological Gardens moved three female and one male African Elephants to a newly constructed barn and large elephant yard, utilizing a stepwise process in which they were first moved inside a new barn and then released into the new yard through a series of increasing sized outside enclosures. The four elephants were observed for a period of two years totaling 357 hours of observation: 12 weeks of baseline data and 17 weeks of post translocation observations. Elephants were observed using 20 min focal animal sampling using a single subject observational design. Twenty-four different behaviors were measured across five different environments. Data were analyzed using both ANOVA and analysis of graphs of each behavior averaged in 1-week bins.

Moving the elephants in stages allowed the potentially hazardous behaviors of the initial translocation to occur in the protective environment of the barn and not to occur in the spacious and more hazardous new yard, in a fashion similar to soft release in wild translocation studies. The behavioral indicators of stress lasted for 4-6 weeks after translocation. Included is an analysis of gross behavioral changes, stress

related behaviors, social changes, and translocation success. Larger enclosures produced an increase in social behaviors and a decrease in abnormal stereotypic behaviors. One female and the male increased their social behaviors, including the addition of some overtly sexually related behaviors. However, another female stopped her normal sex hormone cycling due to translocation. All together the elephants appear to be in an improved state after the translocation.

TABLE OF CONTENTS

Chapter	Page
I. INTRODUCTION	1
II. METHODS	7
Participants	7
Research Design	8
Procedure	12
Ethogram	16
III. RESULTS	19
Non-social State Behaviors	19
Non-Social Event Behaviors	30
Space Use	33
Social Behaviors	35
IV. DISCUSSION	49
Gross Behavioral Changes	49
Stress Related Behaviors	52
Social Changes	55
Translocation Success	58
LIST OF REFERENCES	61
APPENDIX	64
VITA	66

LIST OF FIGURES

Figure	Page
1. Elephants original enclosure. Cows were housed in this yard.	9
2. Elephants original enclosure. The Bull elephant was kept in this yard.	10
3. Elephants New Barn. Cows were kept in these enclosures.	10
4. Tonka's new enclosure.	11
5. Cow's new enclosure.	13
6. Average Weekly percentage of time Jana spends Standing.	19
7. Average Weekly percentage of time Mamie spends Standing.	20
8. Average Weekly percentage of time Ellie spends Standing.	21
9. Average Weekly percentage of time Jana spends Swaying.	22
10. Average Weekly percentage of time Ellie spends Swaying.	23
11. Average Weekly percentage of time the cows spend Resting.	24
12. Average Weekly percentage of time Ellie spends Feeding.	25
13. Average Weekly percentage of time Ellie spends Foraging.	26
14. Average Weekly percentage of time Jana spends Moving.	27
15. Average Weekly percentage of time Jana spends performing other activities.	28
16. Average Weekly percentage of time Mamie spends performing other activities.	29
17. Average Weekly percentage of time Ellie spends performing other activities.	29
18. Frequency per min. Ellie was observed urinating and/or defecating.	30

19.	Frequency per min. Mamie was observed urinating and/or defecating.	31
20.	Frequency per min. Jana was observed urinating and/or defecating.	31
21.	Frequency per minute Ellie was observed performing coprophagia.	32
22.	Average Weekly percentage of time Jana spends in each location.	33
23.	Average Weekly percentage of time Mamie spends in each location.	34
24.	Average Weekly percentage of time Ellie spends in each location.	35
25.	Average Weekly percentage of time Jana spends in spatial proximity to the other elephants individually.	36
26.	Average Weekly percentage of time Mamie spends in spatial proximity to the other elephants individually.	37
27.	Average Weekly percentage of time Ellie spends in spatial proximity to the other elephants individually.	38
28.	Average Weekly percentage of time Ellie spends in spatial proximity to Tonka	39
29.	Average Weekly percentage of time Tonka spends in spatial proximity to the other elephants individually.	40
30.	Frequency per minute Jana was observed physically contacting the other elephants individually.	41
31.	Frequency per minute Mamie was observed physically contacting the other elephants individually.	41
32.	Frequency per minute Jana was observed displacing the other elephants individually.	42
33.	Frequency per minute Mamie was observed displacing the other elephants individually.	42
34.	Frequency per minute Ellie was observed avoiding the other elephants individually.	43

35.	Average weekly percentage of time the cows were observed in spatial proximity to Tonka.	44
36.	Frequency per minute Jana was observed touching Tonka with her trunk.	45
37.	Frequency per minute Ellie was observed touching Tonka with her trunk.	46
38.	Frequency per minute Tonka was observed touching the cows with his trunk.	47
39.	Frequency per minute Tonka was observed touching Ellie with his trunk.	47
40.	Frequency per minute Tonka was observed touching Jana with his trunk.	48

CHAPTER I

INTRODUCTION

Translocation, the transfer of animals from one location to another, is an important aspect of captivity. Heidiger (1969) argued that while a whole book could be written on this subject it is ironic that very little had been done to scientifically explore this topic. While some scientific studies have been done on the topic very little has been published on the topic since Heidiger's observation. The purpose of this study was to add to the scientific literature on captive large mammal translocation through behavioral observation of a captive group of African elephants, *Loxodonta africana*, that were moved from one exhibit to another within the zoo.

Knoxville Zoological Gardens moved three cows and one bull African elephant to a newly constructed barn and elephant yard that is much larger than the facilities they were in previously. When captive animals are moved to a new environment, the organization that cares for them desires answers to questions like these: What are the behavioral changes that occur when a captive elephant is moved from one environment to another? How long after a move do the elephants exhibit signs of stress from being in the new environment? How does the move affect their social structure? How does an increase in availability of a bull elephant affect the behaviors of a group of cows who previously had limited contact with the bull? Are these elephants in a state of enhanced psychological well being and better off due to their new environment, and was it worth the resources the Zoo put into the creation of the environment and translocation of the animals to it? This study attempts to answer

the above questions by observing changes in the elephants behavior after the move occurred.

Heidiger (1969) described the process of an animal making its entrance into its new living quarters as 'full of drama'. The typical reaction of the transport cage being opened into the new enclosure was observed as: Some animals bolt around the new enclosure possibly injuring themselves in the process, while others cling to the transport enclosure and refuse to leave it. Knoxville Zoological Gardens keepers observed similar behavioral patterns when assisting the introduction of chimpanzees to a new enclosure at the Knoxville Zoo (Personal communication, August 17, 2002). Chimpanzees who had lived most of their captive lives on concrete and hay were wary of the grass of the new enclosure and took several weeks to actually fully explore their new environment.

Heidiger (1969) did not actually present a formal study of any particular animal transfer in zoos but he called for future scientists to undertake such research. "Despite the fact that thousands of animals are transferred every year in zoos around the world, little or no knowledge is gained from them." He blamed the lack of study on the use of zoos as an attraction of economy in which the scientific side of the zoos function is reduced to lowest cost. Heidiger emphasized the important research on exploratory behavior in animals. When animals first enter the new enclosure each species used its particular senses to explore the new environment. However, this did not extend to long-term behavior, and no research has been published regarding African elephant exploratory behavior. Second he emphasized that moving animals is a stressful event, including an elephant plagued with diarrhea after a plane flight to a

new zoo. This stress could last for long periods after introduction to the new environment. Third he pointed out that transfer is one of the leading causes of 'death due to behavior' where animals die of shock after being introduced to a new enclosure. Finally he made warnings about the effects of transfer on social behavior. He warned against introducing animals to enclosures that are already inhabited. These cases always end up in aggression in one form or another and can be very dangerous.

Current published studies of animal translocation have focused on the effects of enclosure size on abnormal behavior. Barbara Lester (1997) studied the relocation of a number of different old world monkeys from a normal zoo exhibit to smaller temporary holding cages while a new primate building was being built at Houston Zoological Gardens. She hypothesized that the animals would undergo stress due to a forced environmental change, specifically enclosure novelty, spatial crowding, and lack of privacy.

Lester (1997) focused on the animal's lack of control over the relocation to the new location as one of the most stressful events the animal's experience. While she addressed hormonal indicators of stress as a possible measure she chose to focus on behavioral indicators. Stress due to overcrowding was hypothesized to cause increases in aggression and sexual behaviors. Animals with lower levels of stress are seen taking moments away from other members of the group interacting with the environment. Therefore it could be hypothesized that stress will lead to a decrease in environmental interaction in chimpanzees and possibly in other mammals such as elephants as well.

Lester (1997) found an increase in environmental exploration when animals were moved to larger enclosures. During the first move a decrease in environmental exploration was observed when animals were placed in smaller enclosures, however, an increase was found when animals were placed in a larger enclosure. This seems to support that the hypothesis relating crowding to exploration behaviors is reversible.

Lester (1997) found increases in aggressive and dominance behaviors after the animals were translocated. Lester also found a decrease in resting behaviors. Finally Lester did not find any differences in behavior for animals that were raised as solitary individuals.

Similar behavioral changes were found in chimpanzees due to change in environment (Clarke, Juno, & Maple, 1982). They observed a small group of chimpanzees as they were moved from a laboratory environment to a naturalistic man made Island. Two of the four chimpanzees studied decreased their motion stereotypy when moved to the area with more space available. The other two showed no motion stereotypy in either environment. Self directed behavior dramatically decreased and there was an increase in social play in the larger environment. Overall their research was deemed a success, as the animals utilized their whole island and began to exhibit more social behaviors.

A number of studies in wild populations have used translocation to examine social changes. Zucker (1984) examined courtship behavior in fiddler crabs *Uca Musica Terpsichores*. He found that when you took a dominant male from a small population area and translocated it to a large population area where the dominant males were physically larger the crabs arrested their courtship behavior until they

grew larger. Ostro, Silver, Koontz, Horwich, and Brockett (2001) examined how social structure shifted in Black Howler monkeys *Alouatta pigra* when translocated to areas of differing population densities. At higher densities the monkeys grouped in larger groups with multiple males and females, while at low density monkeys separated into pairs. Changing environments can lead to drastic changes in social behavior.

While no studies have been done relating translocation and changes in African elephant behavior, there is evidence to suggest their social structure will change in predictable ways. Douglas-Hamilton (1975) describes the basic unit of elephant society, the family, as consists of a cow, her teenage offspring, juveniles, and calves of both sexes. Often a number of mature cows which are related to each other being either mothers, daughters, sisters, ect. Band together into kinship groups. Sometimes one cow, the matriarch, leads the herd. In times of trouble she will defend the group and the others react as she does, if she runs they run and if she attacks they will all charge. In more peaceful times she decides where the families go when they move and when they sleep. Among the family units following the matriarch, older cows begin to establish themselves as matriarchs of their own family unit. Douglas-Hamilton (1973) suggests that optimal group size is a function of defensive grouping and competitive dispersion. When times are difficult and food & water sources are low, predator pressure increases and the family units band closer together for protection.

Eltringham (1982) supports this idea with his own observation that in area where hunting and poaching is heavy the mean group size of elephants is higher than

normal. These studies suggest that as captive cows are moved in the zoo setting, larger enclosures with greater resources might cause a shift in the social behaviors of the cows. I hypothesized that some cows may spread apart either on their own or by force from the others.

In summary, translocation of captive animals is typically a stressful process that can lead to gross behavioral changes (Heidiger, 1969; Massot et al., 1994). The initial move can be stressful enough to injure or kill an animal so great care and planning should be taken. Specifically this stress has some relation to enclosure size. For species formally studied, (Lester, 1997; Clarke, Juno, & Maple, 1982), in smaller enclosures exploratory behavior decreases, self-directed behavior increases, and abnormal stereotypic behaviors increase. While in larger enclosures the stress dissipates faster leading to increased exploration, decreased stereotypic behaviors, and increases in social behaviors. We expect there to be a change in cow social behaviors, including a possible separation of cows into different social groups as enclosure size increases.

CHAPTER II

METHODS

Participants

The Knoxville Zoological Gardens houses four *Loxodonta africana*. One bull African elephant, Tonka began the study at 22 yrs of age. Tonka was wild born in South Africa. He was purchased from Ferndale: international animal exchange inc. at the age of around three years and had been a part of the collection for 19 yrs.

The α cow at the zoo is 21 yr old Jana. Jana was wild born in Cape Town, South Africa. Jana was on loan from the Louisville Zoological garden to be mated with Tonka. Jana had been at the Knoxville zoo for 3 yrs.

The β cow at the zoo is actually the eldest cow Mamie. Mamie began the study at 38 yrs old. Mamie's birth location is unknown but due to the lack of success in captive breeding it is assumed she was captive born. Mamie was donated to the Knoxville zoo from Buffalo Zoological Gardens and had been a part of the collection for 22 years.

The third cow in the study was the youngest cow Ellie. Ellie began the study at 15 years of age. Ellie was captive born at an unknown location. Ellie was currently on loan from Gulf Breeze and had been a part of the collection for 2 yrs. Ellie had some special history variables that will affect her behavior. Ellie spent her years at Gulf Breeze in social isolation. When first loaned to the Knoxville zoo it was observed that she did not have any of the normal elephant social behaviors such as trunk touching, and appropriate approach and avoidance which led her to become the object of aggression from the other two cows. She exhibited a large number of

atypical behaviors such as coprophagia and backwards walking, she ate less than half as often as other cows and urinated/defecated over twice as often. Great effort was made by the zookeepers to improve her relations with the other elephants and improve her overall health.

The study spanned approximately a 2-year period and all ages and times should be increased by this amount to reflect final figures.

Research Design

A repeated measures single subject observational design was used so that each elephant was considered a replication of the other subjects. All behaviors used as dependent variables can be found in the ethogram sub-section. The independent variable of this study is the enclosure in which the animals were observed. The Zoo moved the elephants in a series of stages, therefore, the enclosures have been assigned an ordinal variable that reflects each stage of the moving process:

1=original enclosure; The cows original enclosure measures approximately 740 m² and is diagramed as figure 1., Tonka's original enclosure measures approximately 370 m² and is diagramed as figure 2.

2=inside the new barn; the cows housing in the new barn measures approximately 200 m² and is diagramed as figure 3. Their housing has four individual enclosures that each measure 50 m². Tonka was not observed in this area because his barn housing was outside the view of the public and therefore the research committee at the zoo did not approve his study in this location.

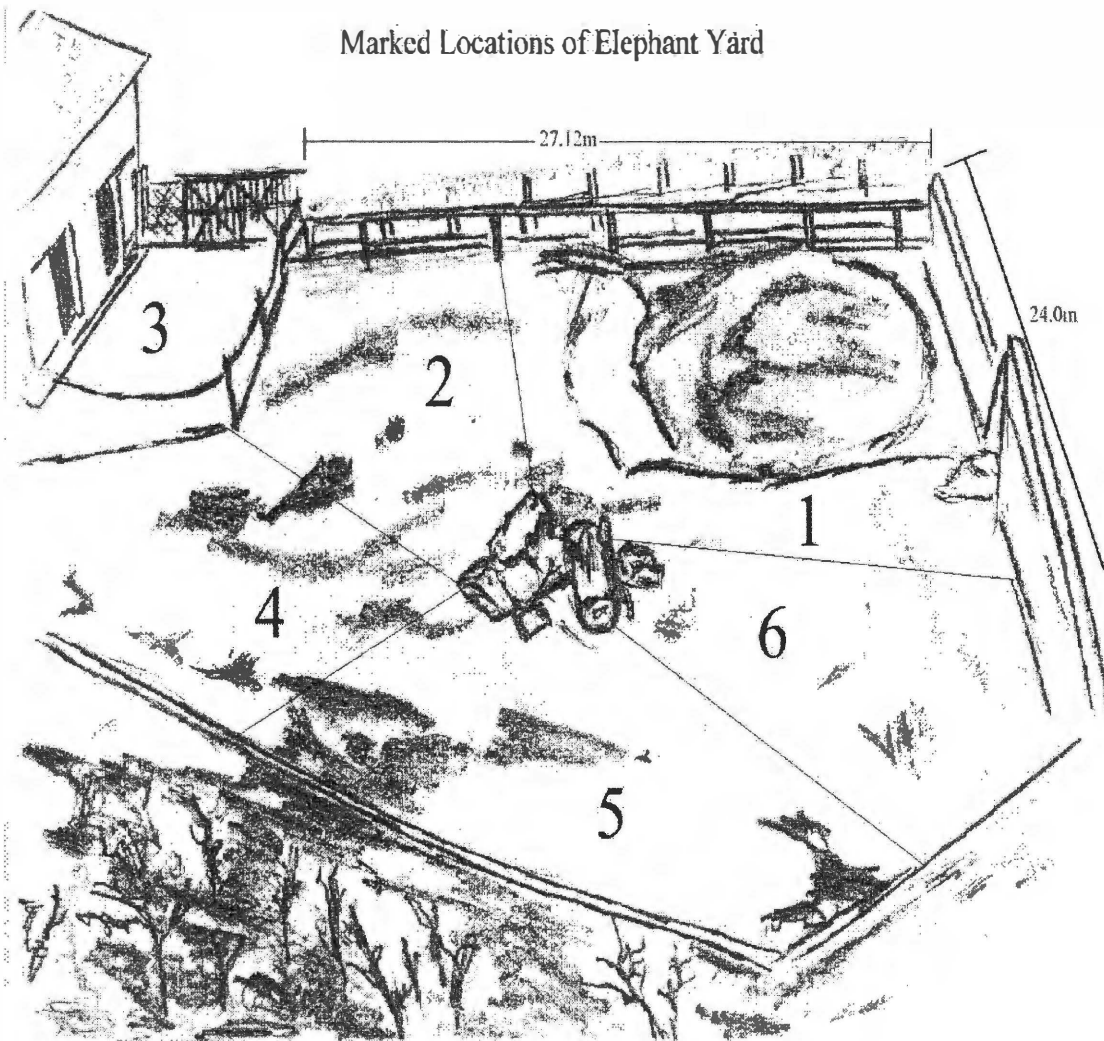


Figure 1. Elephants original enclosure. Cows were housed in this yard. Numbers represent locations assigned to track elephant space use. The figure is not drawn to scale. Total area is approximately 740 m².

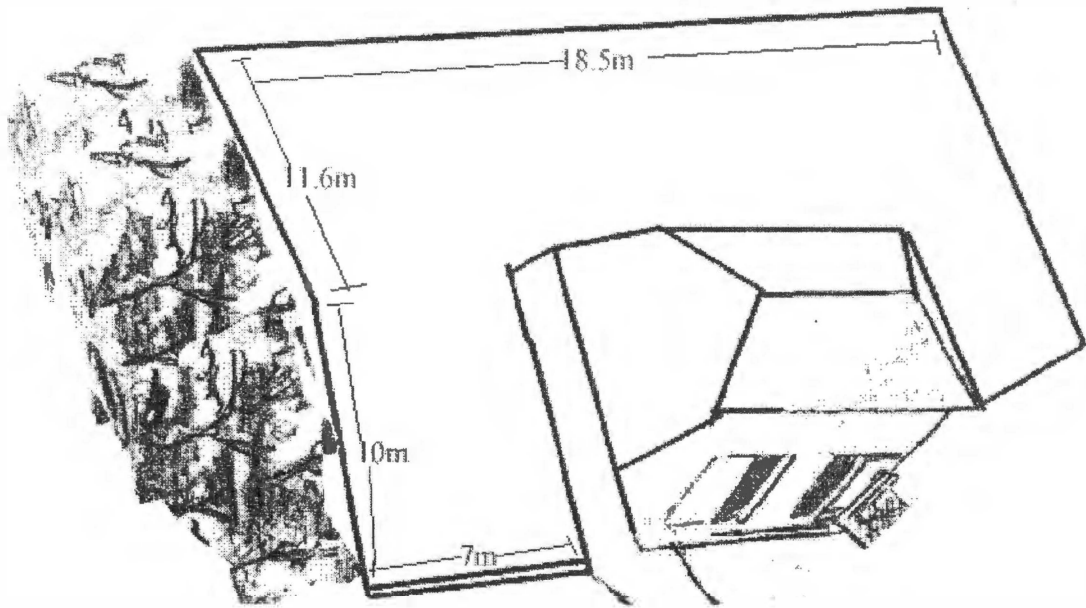


Figure 2. Elephants original enclosure. The Bull elephant was kept in this yard. The figure is not drawn to scale. Total area is approximately 370 m².

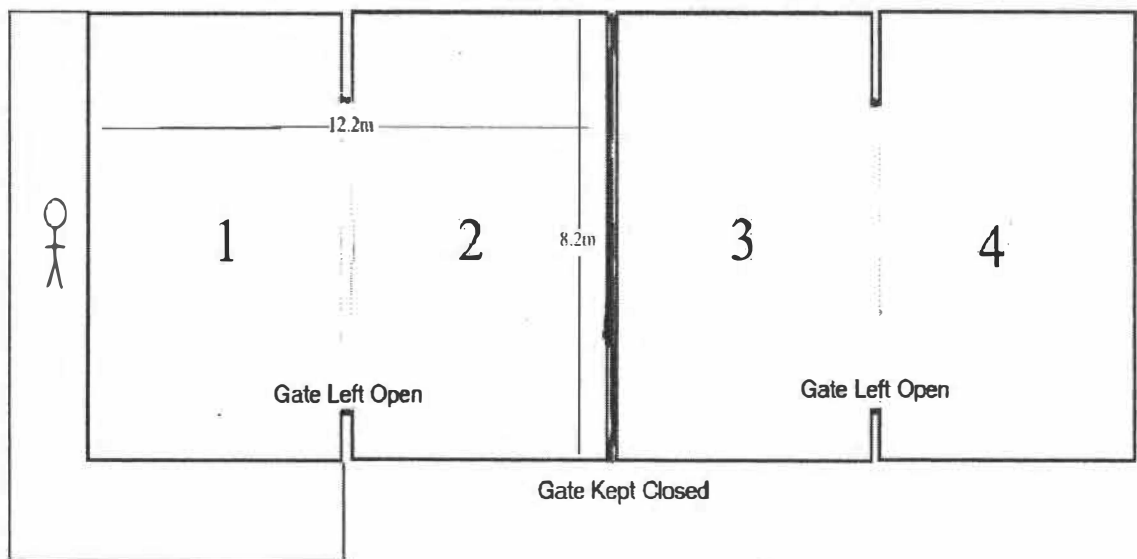


Figure 3. Elephants New Barn. Cows were kept in these enclosures. Numbers represent location numbers assigned to track elephant space use. The figure is not drawn to scale. Total area is approximately 200 m².

3=holding area outside of the new barn; this area is a series of rectangular enclosures directly outside of the new barn. The total enclosure measures approximately 147 m². The enclosure consists of two areas that can be separated measuring approximately 63.4 m² and 83.2 m².

4=Tonka's new enclosure; this area measures approximately 516 m² and is diagramed in figure 4. The cows occupied this area for a while before Tonka was moved out of the barn. Tonka and the cows did not occupy the area at the same time.

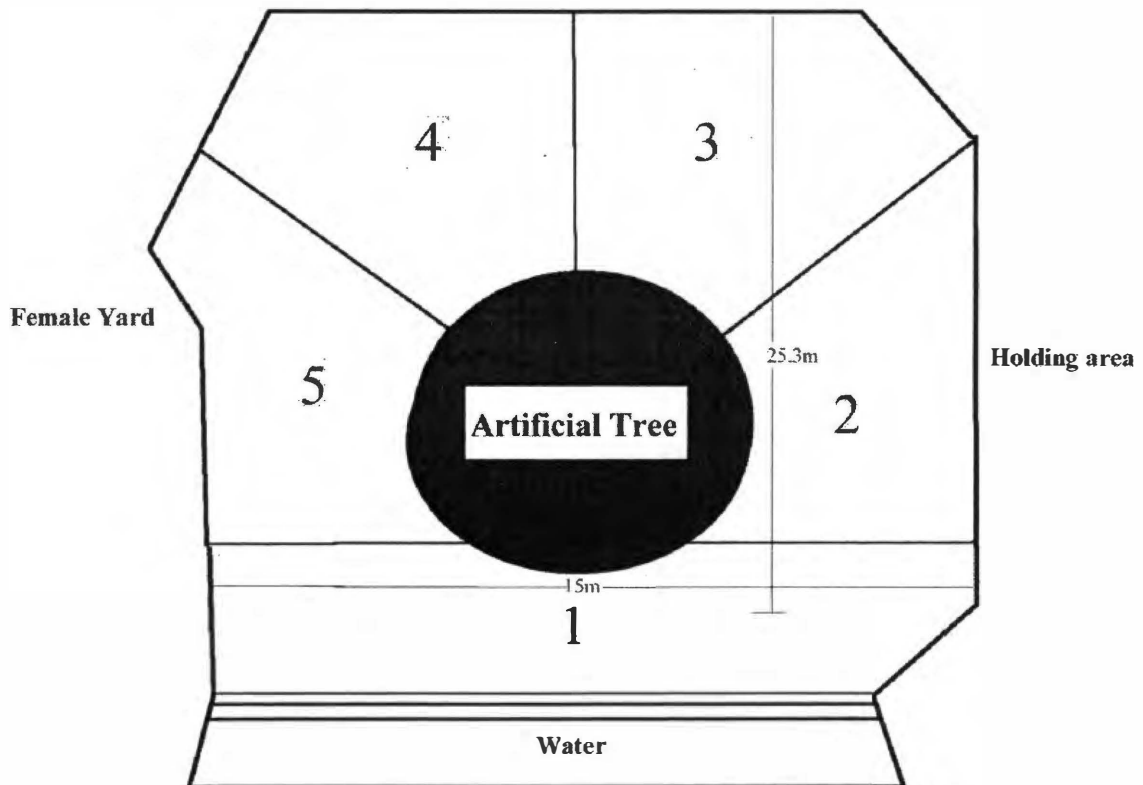


Figure 4. Tonka's new enclosure. Numbers represent location numbers assigned to track elephant space use. The figure is not drawn to scale. Total area is approximately 516 m².

5=Cow's new enclosure; This area measures approximately 1253 m² and is diagramed in figure 5. This enclosure wraps around Tonka's new enclosure allowing the cows' access to Tonka.

Procedure

The four elephants have been observed for a period of one-year totaling 357 usable hours of observation. Observational data was gathered three times a day, seven days a week over this period. Elephants were observed using focal animal sampling. Each elephant was observed for twenty minutes at a time. The order of observation was varied using a Latin squares design.

The behaviors recorded were separated into state behaviors that occurred with some duration and event behaviors, which occur over short durations. State behaviors were recorded using instantaneous time sampling with an interval of 15s. This interval was chosen because during pilot studies it was found that shorter interval created a dramatic decrease in the observer's ability to accurately record the behaviors; inter-rater reliabilities decreased. Event behaviors were recorded continuously as frequency counts. For purposes of analysis state behaviors were reduced to a measure of percentage of observed intervals performing each behavior and event behaviors were reduced to a measure of frequency per unit time. Percentages of observed time was chosen as a measure so that the observation time could be altered in odd circumstances. Pilot observations indicated that keepers

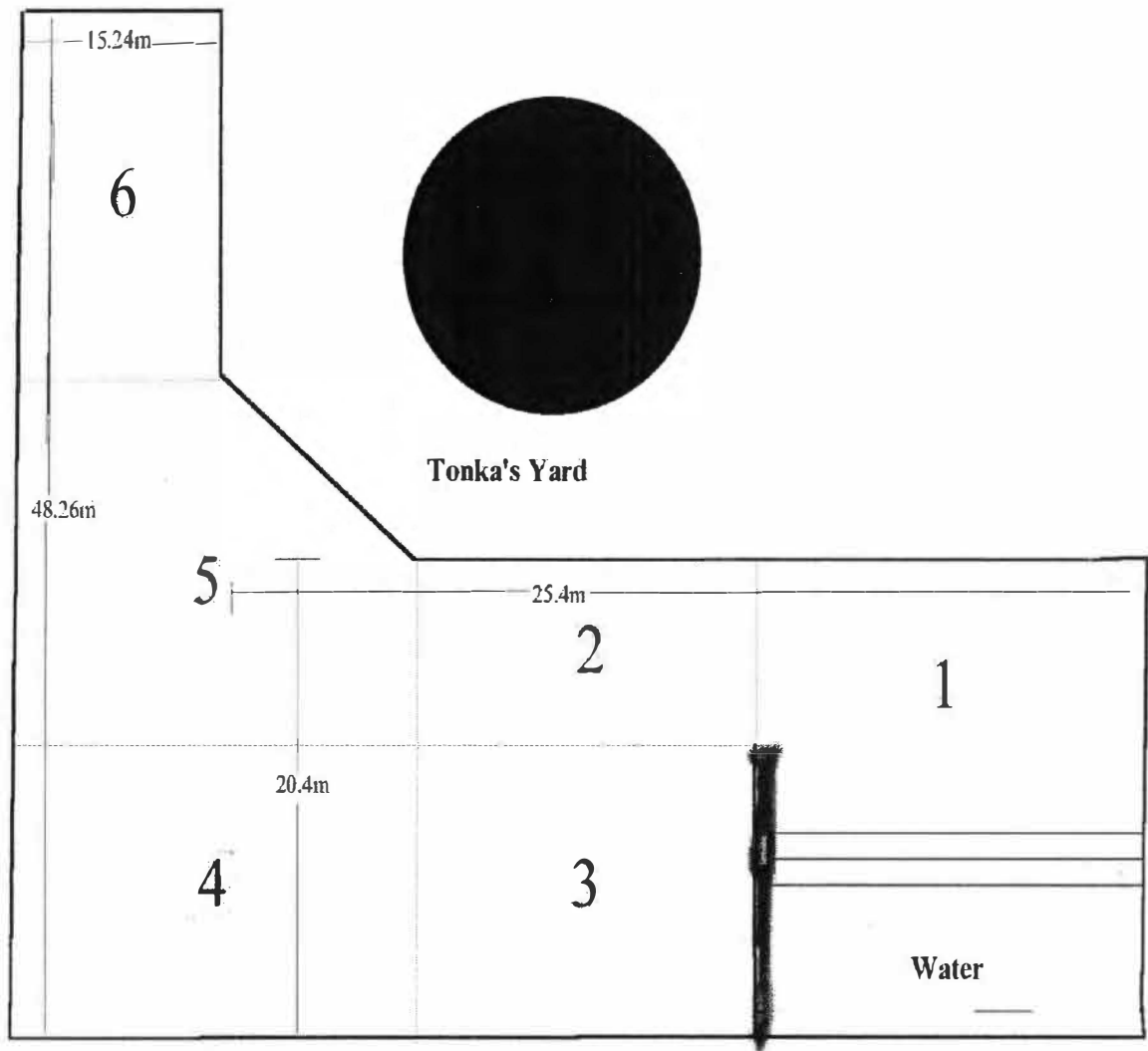


Figure 5. Cow's new enclosure. Numbers represent location numbers assigned to track elephant space use. The figure is not drawn to scale. Total area is approximately 1253 m².

frequently change the elephants' routine and sometimes elephants are removed from the observation area before the observation time is complete.

The study began with the training of observers during August of 2001. Observers were undergraduate students studying psychology or biology who received credit for participating in a laboratory practicum. The primary researcher provided them with an initial three step training program. First observers were introduced to the ethogram and shown videos of elephant behaviors. Questions were answered and they were given a chance to practice observing the elephants on the video. Second the observers were taken to the zoo and introduced to on site protocol. They were familiarized with the area they were going to be observing the elephants in as well as the physical features of the individual elephants so they could differentiate them from one another. Then they performed several observations with the primary researcher allowing them to be verbally tested and monitored. Finally after a week of practice observing observers were tested for reliability with the primary observer. When all of their behaviors matched the primary researcher with an 80% reliability or better they were allowed to begin real observations. During the course of their observing they occasionally met with each other to observe synchronously so that inter rater reliabilities could be measured between them.

Observers signed up in advance for one of three observation blocks each day. They either observed from 10:00-11:30, 11:30-1:00, or 1:00-2:30. They rotated which elephant they watched in what order using a latin squares design. In this manner each elephant was observed between one and three times every day for the

duration of the study. This excludes university holidays when no observations were made but did not exclude weekends when students continued observations.

Baseline data were gathered until the end of November 2001. Translocation occurred all on one day into the new barn area in mid January. This was convenient because when observations began again on the January 30 2002, the observers for the spring semester had finished training using video tapes and were ready to begin collecting data. Observations were not allowed during a 1-2 week period directly after initial translocation of the elephants, as their behavior was deemed too dangerous for any person who was not a zookeeper. Observers were some of the first non-elephant keepers allowed to view the elephants in their new location after the dangerous period had passed. Elephants were observed in either the new barn or outside holding area until March 9, 2002 when the cows were first allowed into Tonka's new yard. They were introduced into their own new yard on April 12, 2002 and Tonka was observed outside in his own new yard around the same time period. Observations continued in this fashion throughout the summer semester of 2002 where the observers had been trained for their positions during the previous spring term. The study was terminated June 27 2002 when a new area was opened for the cows use and a new cow was introduced to the group.

Data was entered into a database for future analysis. Observations were averaged into one-week bins for graphical analysis. These bins were designed to start on a Wednesday so that vacation weeks would not appear as non-data in the analysis. One-way ANOVA with post hoc T tests were used to test the differences in behaviors in the five observed locations.

Ethogram

Reviewing previous behavioral research with elephants (Kuhme, 1962; Garai, 1998) and then involving the actual keepers at the zoo, I formulated the following ethogram. The Knoxville Zoo elephants keepers reviewed the ethogram and made suggestions to better reflect the behaviors of this population.

State behaviors (instantaneous time sampling, 15s):

Stand	Elephant remains in one location without swaying its head or performing other score able behaviors. Trunk is curved or moving indicating the animal is not at rest.
Sway	Elephant remains within a few steps of one place and moves it's head back and forth while either remaining in one spot or rocking forward and back in one location.
Rest	Elephant stands in one location with trunk at rest. Trunk may be draped over the tusks or remain motionless straight down. Elephant may lean against something. Tail may continue to move.
Move	The elephant walks or walks fast
Feed / drink	The act of putting things in the mouth and masticating or swallowing them.
Forage	The act of looking for food. Searching over the wall or around the ground for food.
Other	The elephant is doing something not defined. Examples-sand bathing, manipulating tires and other objects

Social behaviors - recorded by indicating the individuals with whom the focal animal was interacting; all but proximity are event behaviors (continuous recording):

- Proximity** The observed elephant is within one body length, including outstretched trunk, of another elephant
- Approach** Walking or running toward another elephant. Head and body oriented toward the second elephant
- O. Approach** Another elephant walks or runs towards the observed elephant.
- Avoidance** The observed elephant moves away from another elephant.
- Displacement** The observed elephant moves to another elephant's feed while the second elephant is feeding and the second elephant moves away (avoidance)

Social Contact – Trunk touching - The elephant touches another elephant with its trunk. Event behaviors (continuous recording):

- Body** Observed elephant touches the head, face, tail or body with its trunk
- Genitals** Observed elephant touches the genital location of a second elephant
- Trunk** The observed elephant touches the trunk of a second elephant
- Mouth** elephant places its trunk in or touches another elephant's mouth
- Over back** The observed elephant places its trunk over the other elephants back
- Ear** The observed elephant touches the ear of a second elephant
- Gland** The observed elephant touches the temporal gland of a second elephant. No actual contact is needed. Score behavior if elephant puts trunk in spatial proximity to the area between the eye and the ear of another elephant.

Maintenance behaviors – Event Behaviors (continuous recording):

Urine/Def the elimination of wastes through urination or defecation

Coprophagia The observed elephant eats it's own feces

Vocalization noises made by the observed elephant

Space Use - State behavior (instantaneous time sampling, 15s):

Location The location within the enclosure as indicated in figures 1-6.

CHAPTER III

RESULTS

Results will be presented beginning with non social state behaviors, then non social event behaviors, then space use and finally social behaviors. Post hoc T tests are in Table 1 in the Appendix. All post hoc tests will be assumed to be $p < 0.05$ if I report that the difference between conditions was significant.

Non-social State Behaviors

The percent time that each elephant spent standing reflects time spent in a less active state. By examining the average weekly percentage Jana spent standing, Figure 6, it appears that there was little change from the starting enclosure and the initial move, conversely, after time was spent in the new yard Jana spent more time standing than she had before.

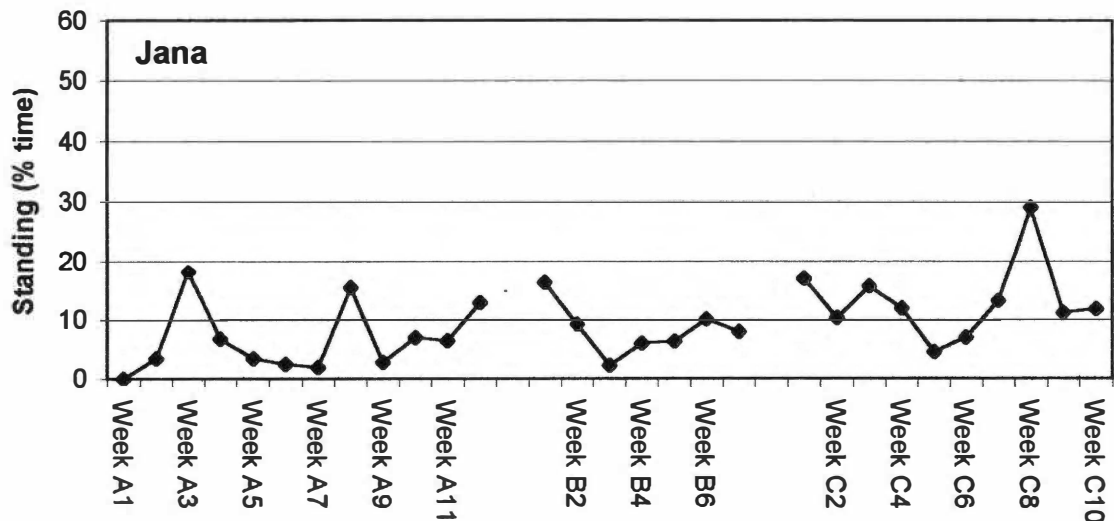


Figure 6. Average Weekly percentage of time Jana spends Standing. The Majority of Observations in Weeks labeled; A are in location 1, B are in location 2,3, or 4, and C are in location 4 or 5.

However, a one way ANOVA found no statistical significance between the average percent time Jana was observed standing in each location; $F(5,308)=1.49$, $p>0.05$, $m1=7.4$, $m2=6.8$, $m3=9.7$, $m4=13.9$, $m5=12.2$.

Mamie provides a slightly different story. Mamie, Figure 7, appears to have increased the time she spent standing greatly when enclosed in the small new barn directly after the initial move returning to normal with some great variance after moving into the new larger yard. A one way ANOVA found a significant difference between the average percent time Mamie was found standing in each location; $F(5,395)=3.15$, $p<0.01$, $m1=25.2$, $m2=42.2$, $m3=40.0$, $m4=37.9$, $m5=35.6$. Mamie spends more time standing in the holding area than her original enclosure. Analysis of trends in Figure 7 reveals that Mamie had an increasing trend in standing behavior directly after translocation.

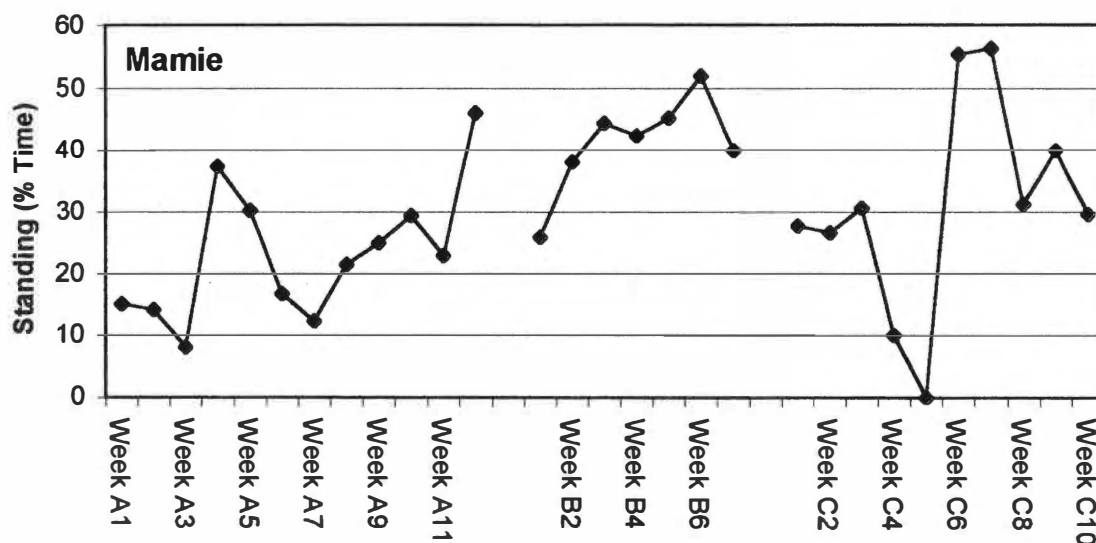


Figure 7. Average Weekly percentage of time Mamie spends Standing. The Majority of Observations in Weeks labeled; A are in location 1, B are in location 2,3, or 4, and C are in location 4 or 5.

Ellie reacted to the move in an opposite manner to Mamie. Ellie spends less time standing after being moved and returned to the initial baseline after spending time in the larger new yard, Figure 8. Ellie was kept in continued isolation for the first several weeks after cows were allowed outside so that when analyzing trends in Figure 8 and most other figures involving Ellie the first four points of the weeks labels C should be considered a part of B. A one way ANOVA found a significant difference between the average percent time Ellie was found standing in each location; $F(5,308)=4.48$, $p<0.01$. Post hoc tests reveal that there is a significant difference in her standing in the bar, holding area, and small yard, $m_2=25.3$ $s_2=23$, $m_3=19.1$ $s_3=21$, $m_4=22.5$ $s_4=27$, and the amount of time she spent standing in the original enclosure or the large, $m_1=34.8$ $s_1=25$, $m_5=35.7$ $s_5=23$.

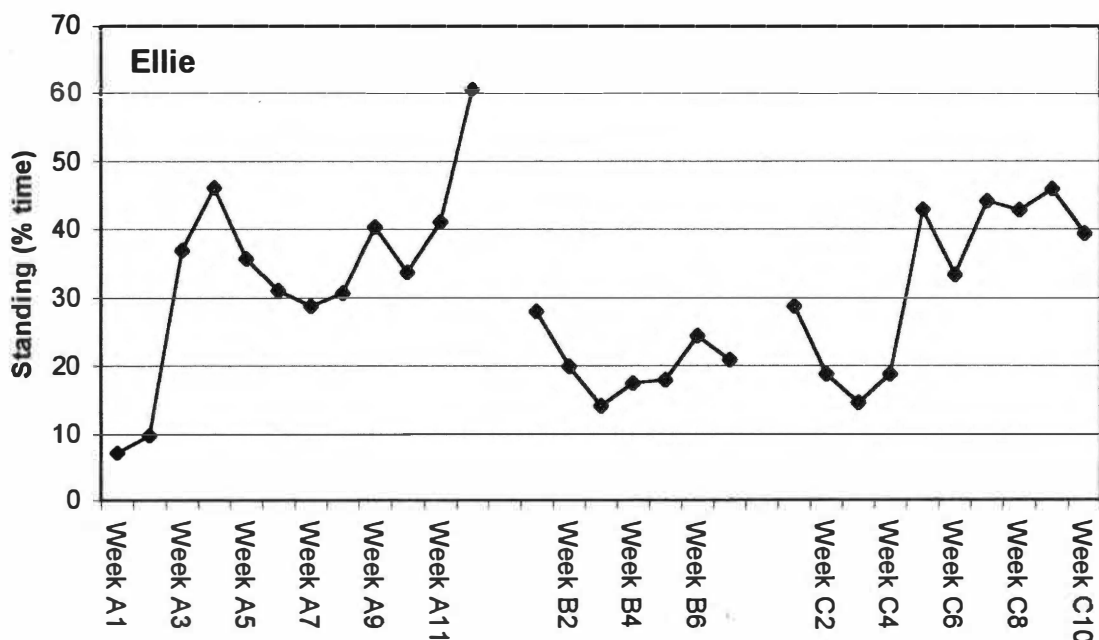


Figure 8. Average Weekly percentage of time Ellie spends Standing. The Majority of Observations in Weeks labeled; A are in location 1, B are in location 2,3, or 4, and C are in location 4 or 5.

Swaying is a stereotypic behavior that by previous research we hypothesized would increase in smaller enclosures and decrease in larger enclosures. By examining the average weekly percentage Jana spent swaying, Figure 9, there was an increasing trend during baseline which lowered slightly after translocation and then there was a sharp increase in this behavior in the outside holding area. This behavior dramatically decreased when allowed into the new larger yards. A one way ANOVA found a significant difference between the average percent time Jana was found swaying in each location; $F(5,308)=7.7$, $p<0.01$. However, there was no increase in either the new barn or the holding area, $m1=29.4$ $s1=33$, $m2=35.9$ $s2=38$, $m3=29.0$ $s3=37$. The decreases in the new yards were significant, $m4=9.5$ $s4=22$, $m5=13.1$ $s5=25$, and testing with a post-hoc Dunnetts T test revealed these to be statistically significant, $p<0.01$.

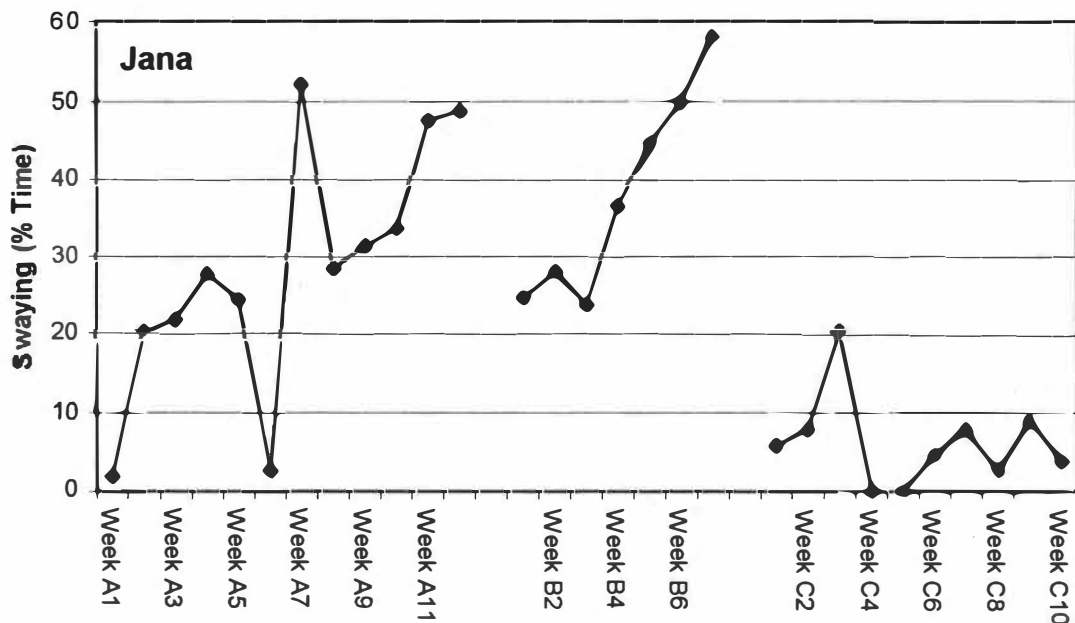


Figure 9. Average Weekly percentage of time Jana spends Swaying. The Majority of Observations in Weeks labeled; A are in location 1, B are in location 2,3, or 4, and C are in location 4 or 5.

Ellie swayed much less than Jana at baseline, changed very little after translocation but had a dramatic increase in the new yards, Figure 10. A one way ANOVA found the increase in the new yard was significant, $F(5,308)=12.97$ $p<0.01$. Post hoc Dunnetts T tests of the One way ANOVA found that her swaying in the new large yard was significantly higher than all other locations, $m1=1.9$ $s1=7$, $m2=3.8$ $s2=6.4$, $m3=4.4$ $s3=13.9$, $m4=3.5$ $s4=5.6$, $m5=13.9$ $s5=18.3$.

Elephants did not sleep while on display very often. While no significant change in resting behavior was found, observers watching the elephants in the first weeks after being allowed into the new barn found an increase in resting behavior that lasted a short amount of time and then returned to baseline Figure 11.

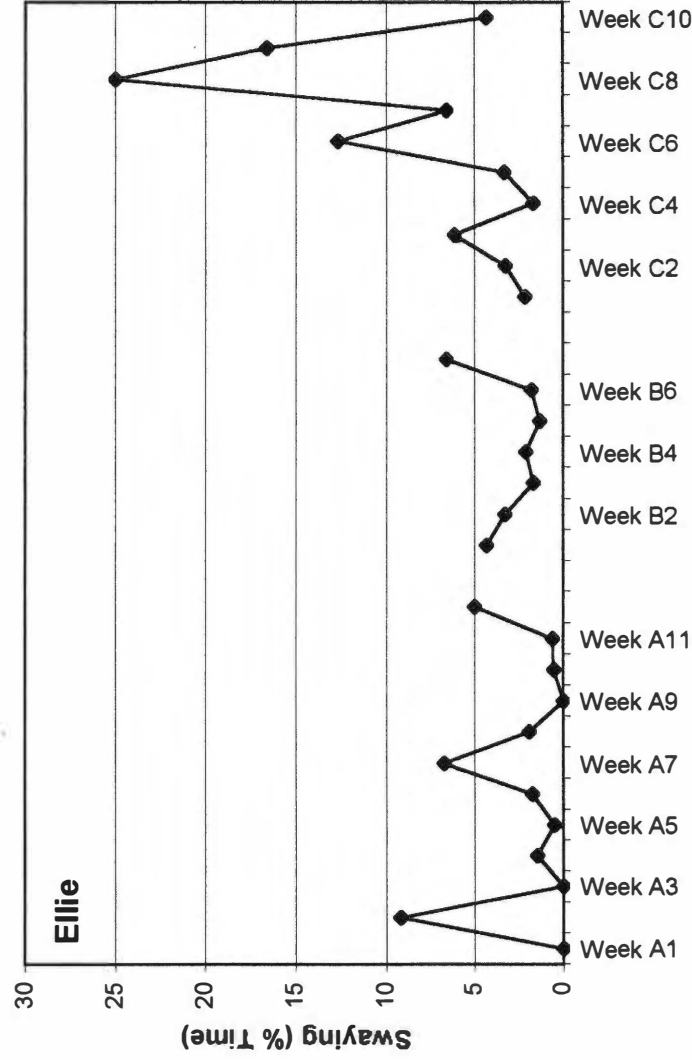


Figure 10. Average Weekly percentage of time Ellie spends Swaying. The Majority of Observations in Weeks labeled; A are in location 1, B are in location 2,3, or 4, and C are in location 4 or 5.

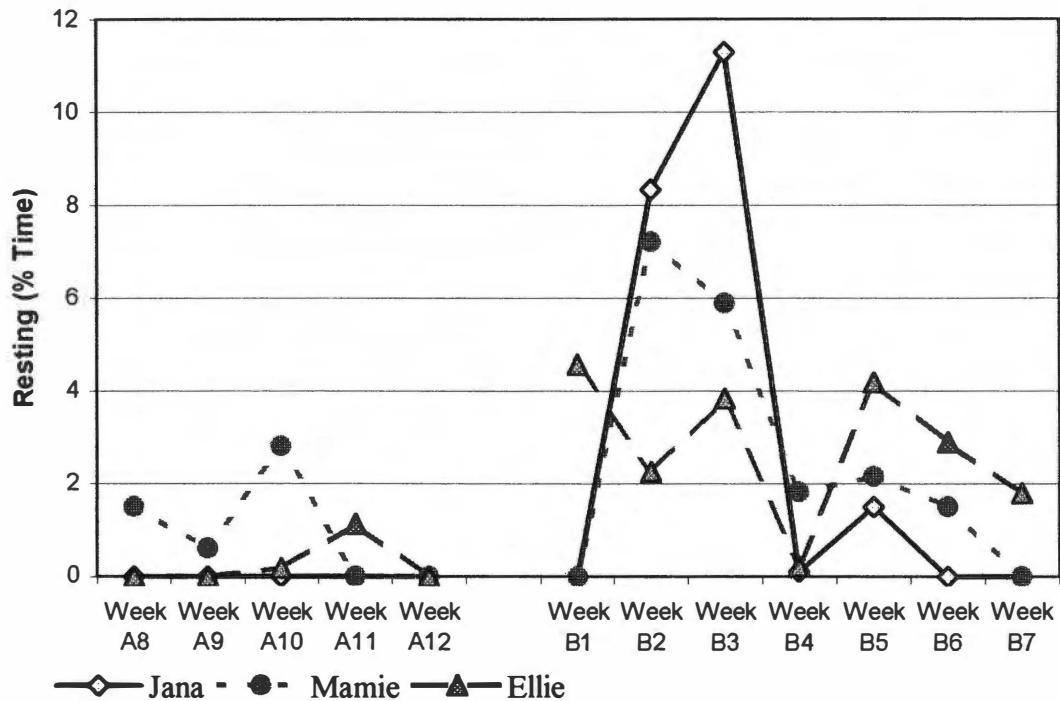


Figure 11. Average Weekly percentage of time the cows spend Resting. The Majority of Observations in Weeks labeled; A are in location 1, and B are in location 2,3, or 4.

Feeding is the behavior all elephants were observed doing most often. While food intake is regulated, food was very prevalent during observation hours. Both Jana and Mamie were found to have a statistically significant change in feeding behavior, Jana $F(5,308)=4.54$, $p<0.05$; Mamie $F(5,395)=4.28$, $p<0.01$. Post hoc T tests reveal Jana had a significant decrease in feeding behavior while inside the barn; $m_1=49.5$, $m_2=29.8$, $m_3=41.5$, $m_4=51.1$, $m_5=48.6$. Mamie did as well; $m_1=41.6$, $m_2=24.2$, $m_3=34.3$, $m_4=37.5$, $m_5=24.7$, and while she appears to also have decreased in feeding behavior in the new yard, post hoc Dunnett's T tests revealed only the decrease inside the barn to be statistically significant.

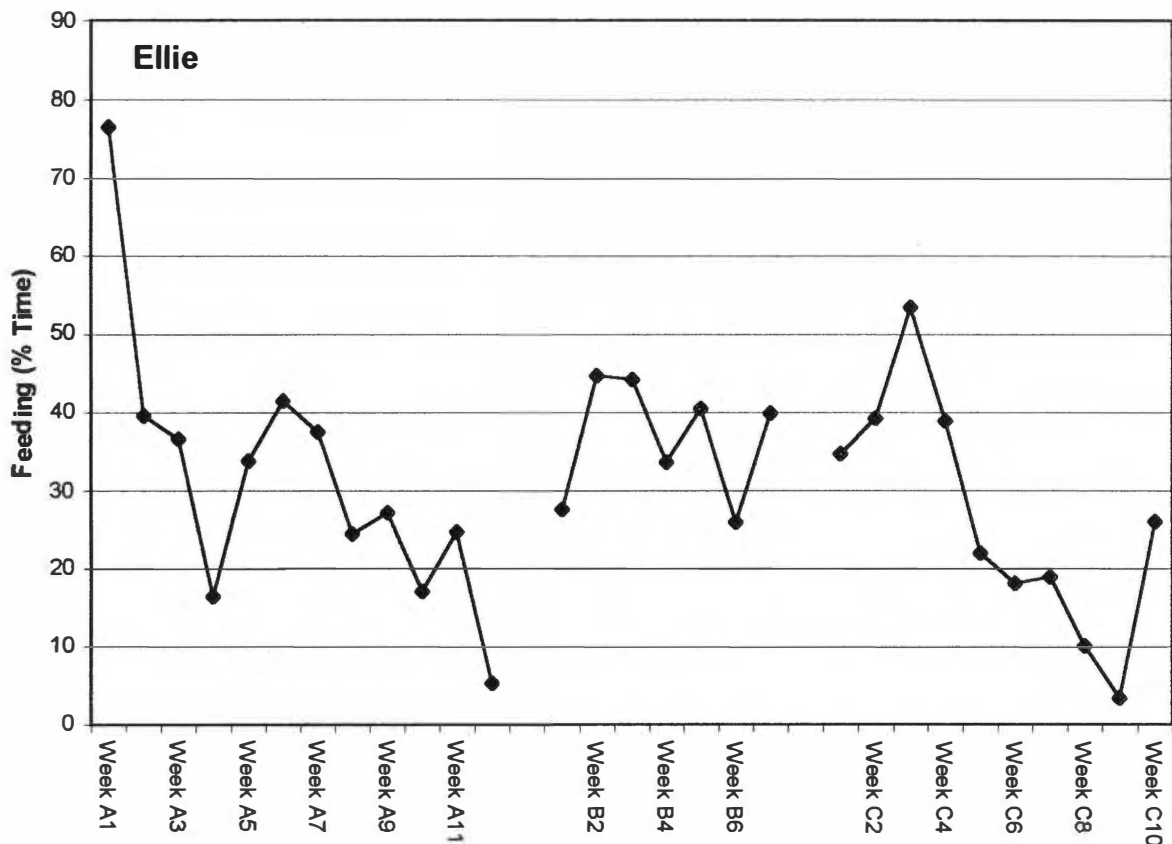


Figure 12. Average Weekly percentage of time Ellie spends Feeding. The Majority of Observations in Weeks labeled; A are in location 1, B are in location 2,3, or 4, and C are in location 4 or 5.

Ellie did not decrease her feeding after the initial translocation but had a sharp decline in the new yards, Figure 12. A one way ANOVA confirmed that the difference, $F(5,308)=7.33$, $p<0.01$. Post hoc Dunnetts T tests revealed that only the decrease in the large yard was significantly different, $m1=30.0$, $m2=32.9$, $m3=40.0$, $m4=43.6$, $m5=17.6$.

Foraging behavior was highly variable and did not seem to change for Jana or Mamie. However, Ellie had a sharp decline in foraging behavior in the new yards similar to her decline in feeding behavior, see figure 13. A one way ANOVA found a significant difference between the average percent time Ellie was found foraging in

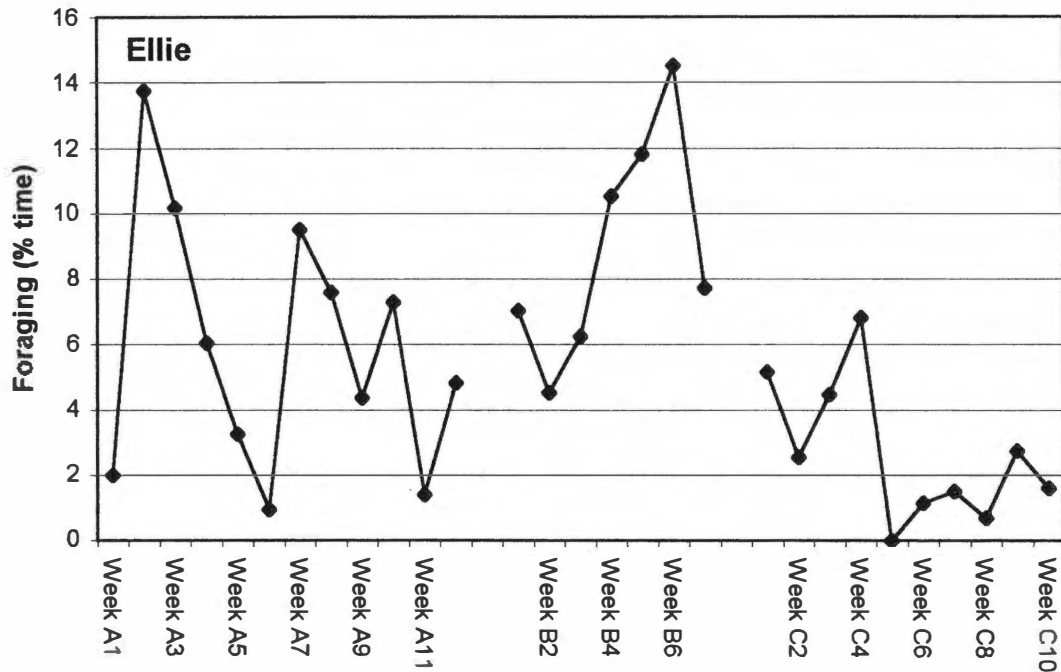


Figure 13. Average Weekly percentage of time Ellie spends Foraging. The Majority of Observations in Weeks labeled; A are in location 1, B are in location 2,3, or 4, and C are in location 4 or 5.

each location; $F(5,308)=6.37$, $p<0.01$, $m1=5.7$, $m2=5.8$, $m3=10$, $m4=5.6$, $m5=1.9$.

Post hoc Dunnetts T tests revealed the significant difference to be the decrease in the new yard.

There was no significant change in the percentage of observed time the elephants spent moving. However for Jana and Mamie there was a sharp brief increase directly following translocation, see figure 14. This was particularly important to note because, this increased occurred within the 100 m² barn stall. These cows moved 2-3 times as often when they were enclosed together in a very tight space. This increase in movement may be indicative of a brief increase in acute stress. This stress dissipated approximately 3-4 weeks after initial translocation.

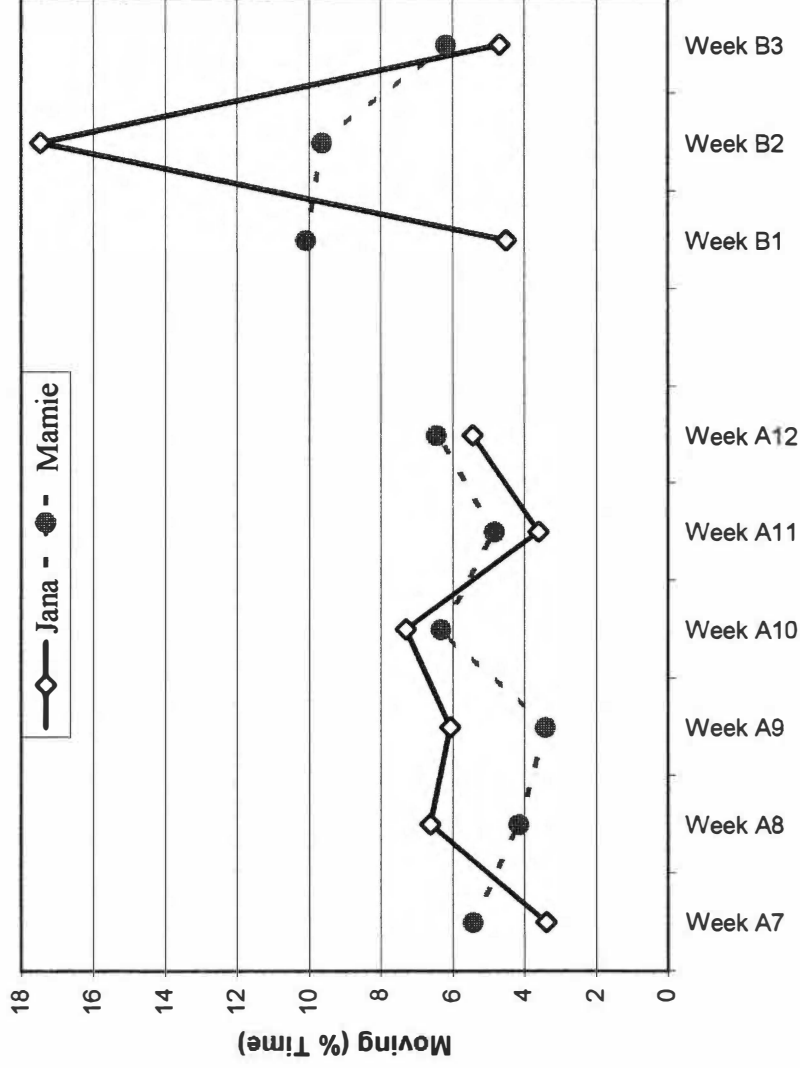


Figure 14. Average Weekly percentage of time Jana spends Moving. The Majority of Observations in Weeks labeled; A are in location 1, B are in location 2,3, or 4, and C are in location 4 or 5.

Other activity was a behavioral category that included a lot of environmental manipulation such as sand bathing, lifting logs, pulling on chains, ect. Jana appears to have increased the percentage of time she performed these other activities as the study progressed with a significant increase in the new larger yard; see Figure 15. A one way ANOVA found a significant difference between the average percent time Jana was found performing other activities in each location; $F(5,308)=8.2, p<0.01$. Post hoc Dunnetts T tests found that the new larger yard, $m5=10.3$ $s5=16.1$, produced significantly more other activity in Jana than the other areas, $m1=1.3$ $s1=4.3$, $m2=2.3$ $s2=4.4$, $m3=5.4$ $s3=13.5$, $m4=9.0$ $s4=9.5$.

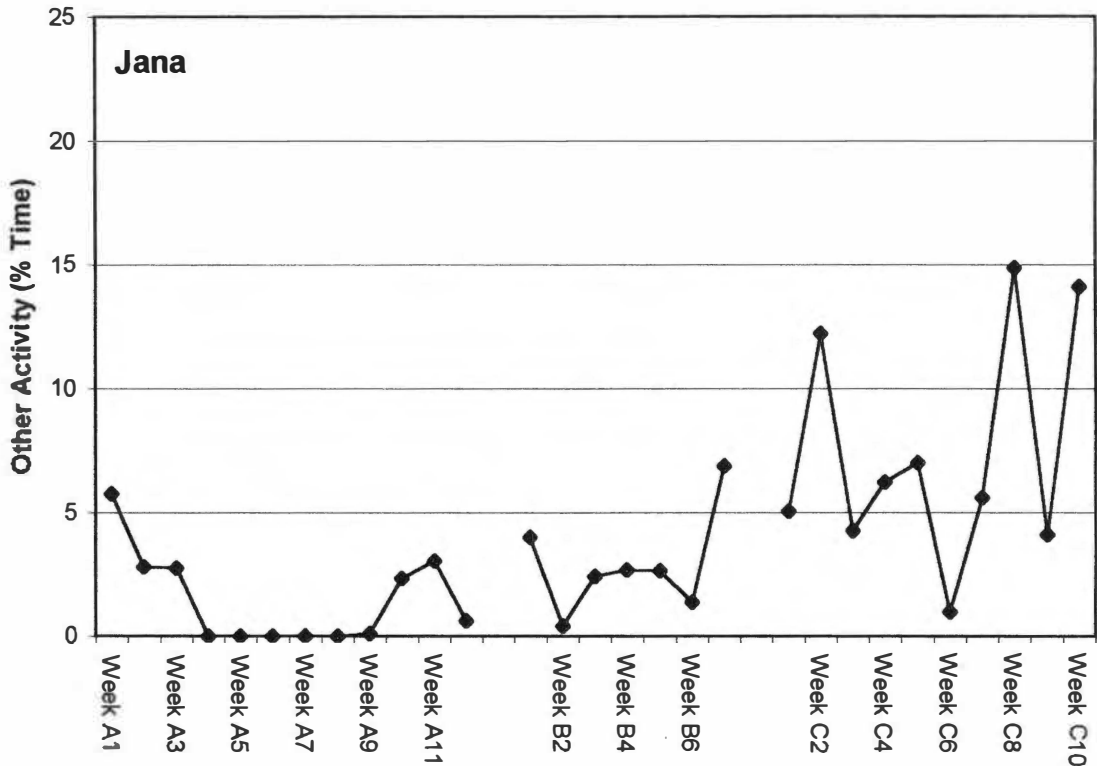


Figure 15. Average Weekly percentage of time Jana spends performing other activities. The Majority of Observations in Weeks labeled; A are in location 1, B are in location 2,3, or 4, and C are in location 4 or 5.

Mamie, Figure 16, and Ellie, Figure 17, replicate the findings of Jana. A one way ANOVA found significant differences for both elephants, $F(5,395)=16.4$ $p<0.01$ & $F(5,308)=5.1$ $p<0.01$ respectively. Mamie spent significantly more time doing other activity in the new larger yard than any other area, $m1=3.7$, $m2=6.1$, $m3=5.2$, $m4=16.9$, $m5=18.25$. Ellie had the same increase but the increase in time spent doing other activity in the new larger yard was only found to be significant over the initial baseline, $m1=5.3$, $m2=10.6$, $m3=8.9$, $m4=7.6$, $m5=11.1$. It is noted that the new yards had significantly more mud than the baseline enclosure resulting in significant increases in sand bathing.

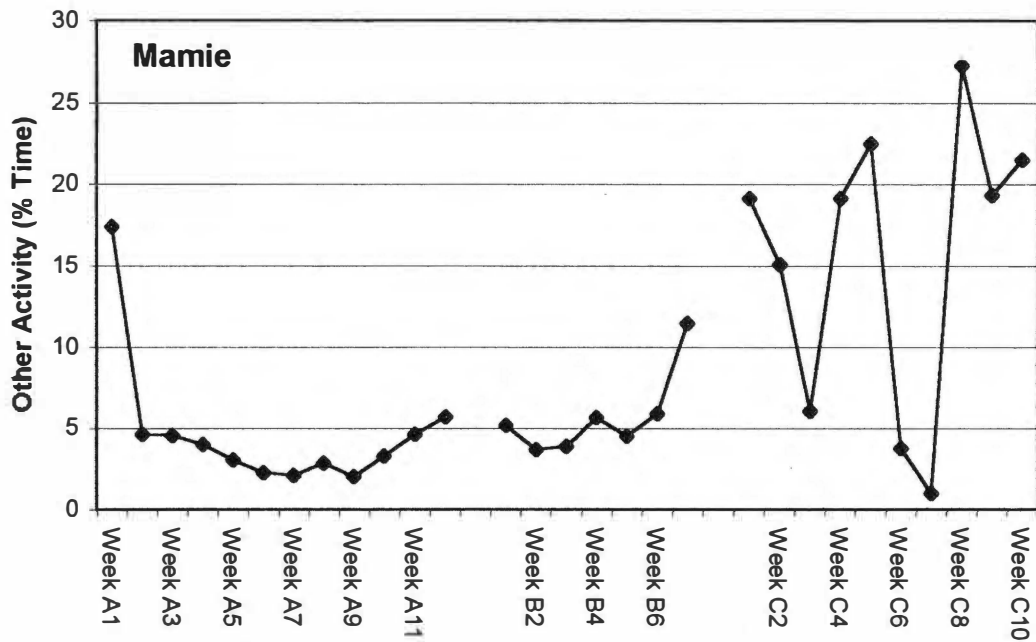


Figure 16. Average Weekly percentage of time Mamie spends performing other activities. The Majority of Observations in Weeks labeled; A are in location 1, B are in location 2,3, or 4, and C are in location 4 or 5.

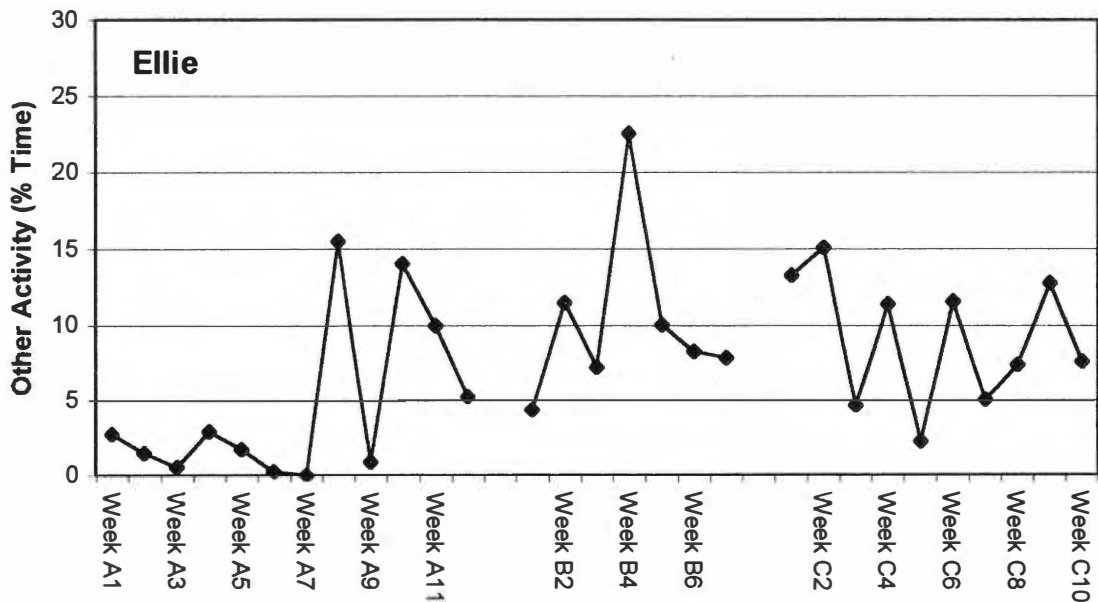


Figure 17. Average Weekly percentage of time Ellie spends performing other activities. The Majority of Observations in Weeks labeled; A are in location 1, B are in location 2,3, or 4, and C are in location 4 or 5.

Non-Social Event Behaviors

Event behaviors must be analyzed differently from state behaviors due to their rare nature. Most of the event behaviors utilized in the ethogram were never observed in this population. Some were removed from analysis due to low inter rater reliability, <80% agreement. Beyond that, the extremely rare nature of their occurrence creates low statistical power. Therefore, there were no significant statistical differences in any non-social event behavior. However there are a few worth noting anyway for giving the lack of statistical power.

When the observation was allowed to continue after translocation, there was an increase in urination and defecation documented in Ellie, Figure 18, and Mamie, Figure 19, but not in Jana, Figure 20.

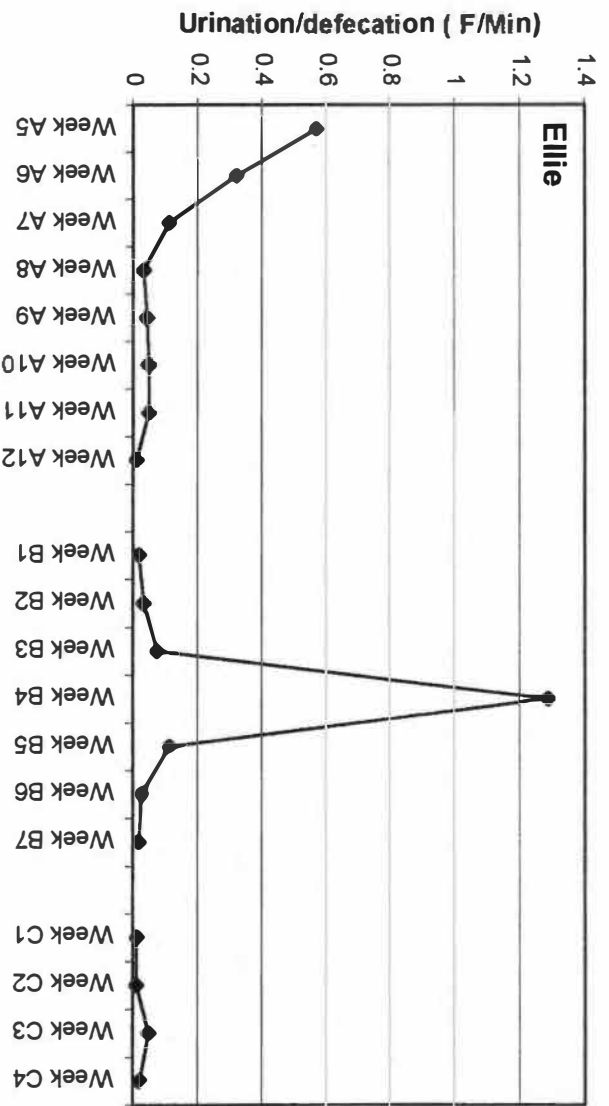


Figure 18. Frequency per min. Ellie was observed urinating and/or defecating. The Majority of Observations in Weeks labeled; A are in location 1, B are in location 2,3, or 4, and C are in location 4 or 5.

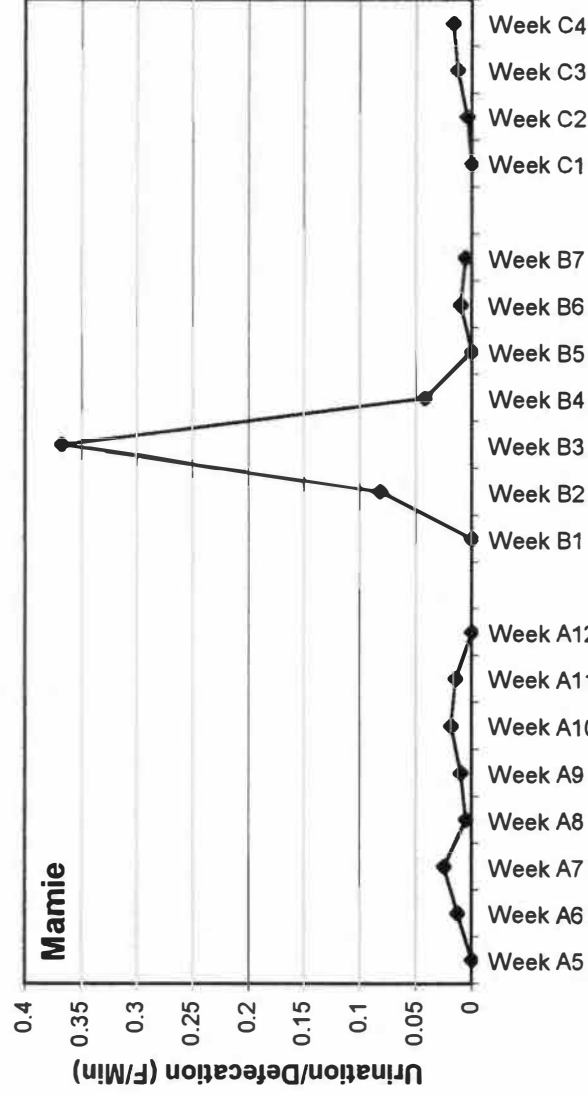


Figure 19. Frequency per min. Mamie was observed urinating and/or defecating. The Majority of Observations in Weeks labeled; A are in location 1, B are in location 2,3, or 4, and C are in location 4 or 5.

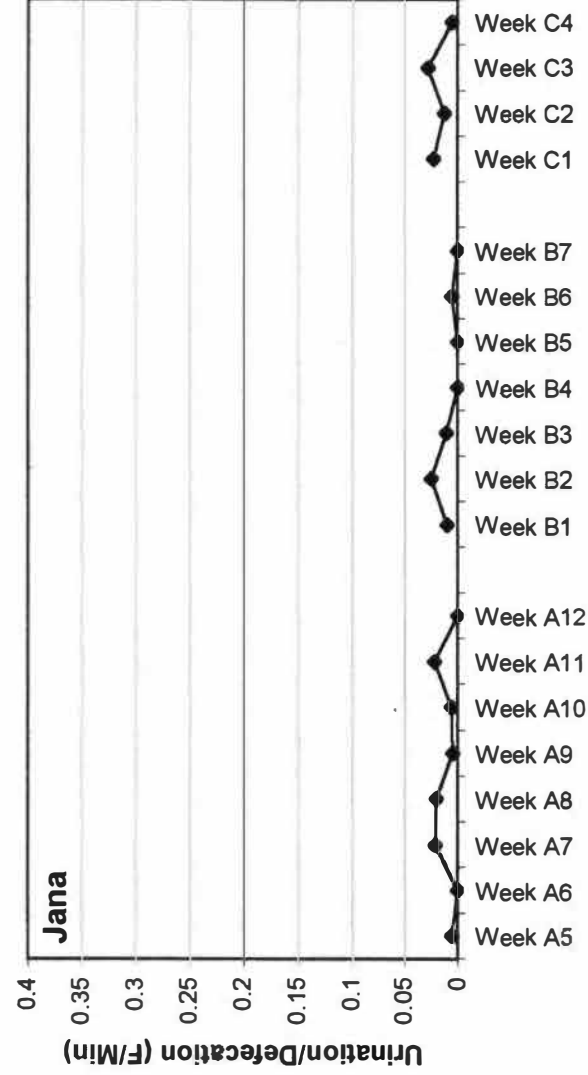


Figure 20. Frequency per minute Jana was observed urinating and/or defecating. The Majority of Observations in Weeks labeled; A are in location 1, B are in location 2,3, or 4, and C are in location 4 or 5.

Coprophagia, the eating of ones own feces, was another important stereotypy we monitored. While this behavior was a rare event at baseline, and only Ellie performed this behavior with regularity, the keepers were actively attempting to train her to stop. Ellie exhibited a relatively large increase in this behavior directly after translocation, which quickly returned to baseline levels, Figure 21. Ellie increased her observed coprophagia from a baseline average of 0.02 occurrences per minute to a peak over 1.8 occurrences a minute during the fourth observed week after translocation. This increase dropped again to an average observed frequency/minute similar to levels observed in the original yard. This assumed stress related behavior also seems to have gone back to original levels after 4-6 weeks after translocation.

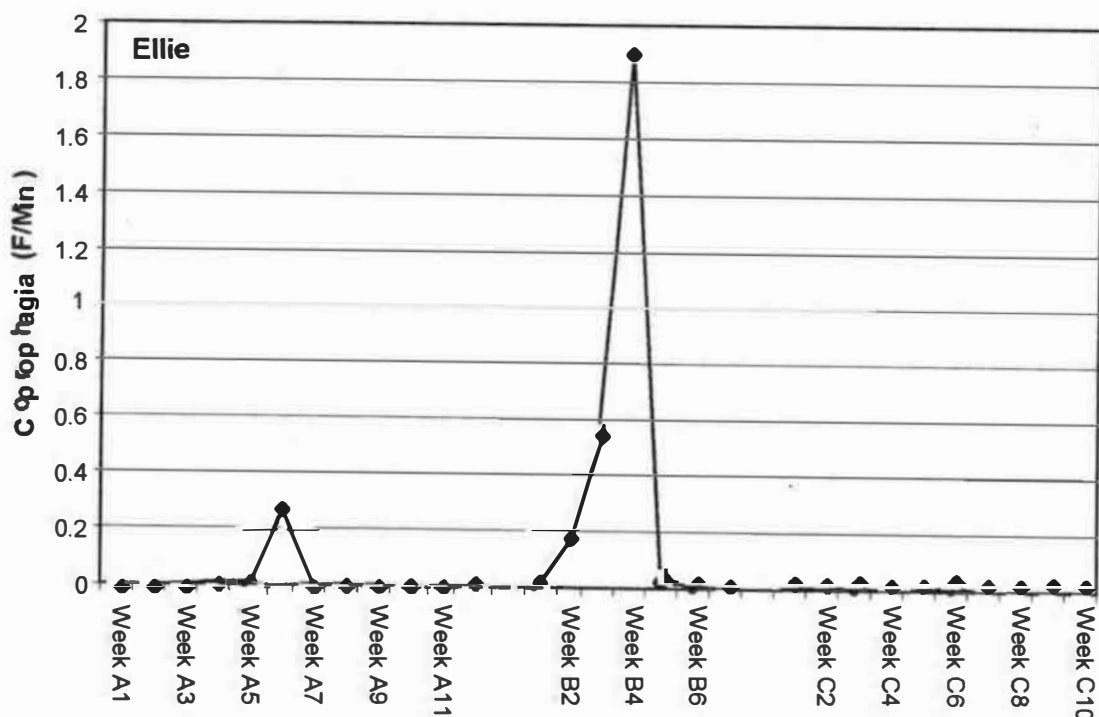


Figure 21. Frequency per minute Ellie was observed performing coprophagia. The Majority of Observations in Weeks labeled; A are in location 1, B are in location 2,3, or 4, and C are in location 4 or 5.

Space Use

Elephants use of space was monitored to look for patterns in use of space and changes that may indicate social changes. The numbered locations are given on the diagrams of each area, Figures 1-5. When in the new barn and the holding are the cows were kept in partial isolation and always in the same limited locations so these have been removed from the analysis. In the original yard, Tonka's new yard and the cow's new yard location 1 is always closest to the water source. In the original yard location 2 was closest to the barn and 4 was closest to Tonka. In the cow's new yard location 6 was closest to the barn and 2 & 5 were closest to Tonka. As seen in Figure 22, Jana defended an area near the water and the barn and moved very little around her enclosure otherwise. After the move she changed locations more often

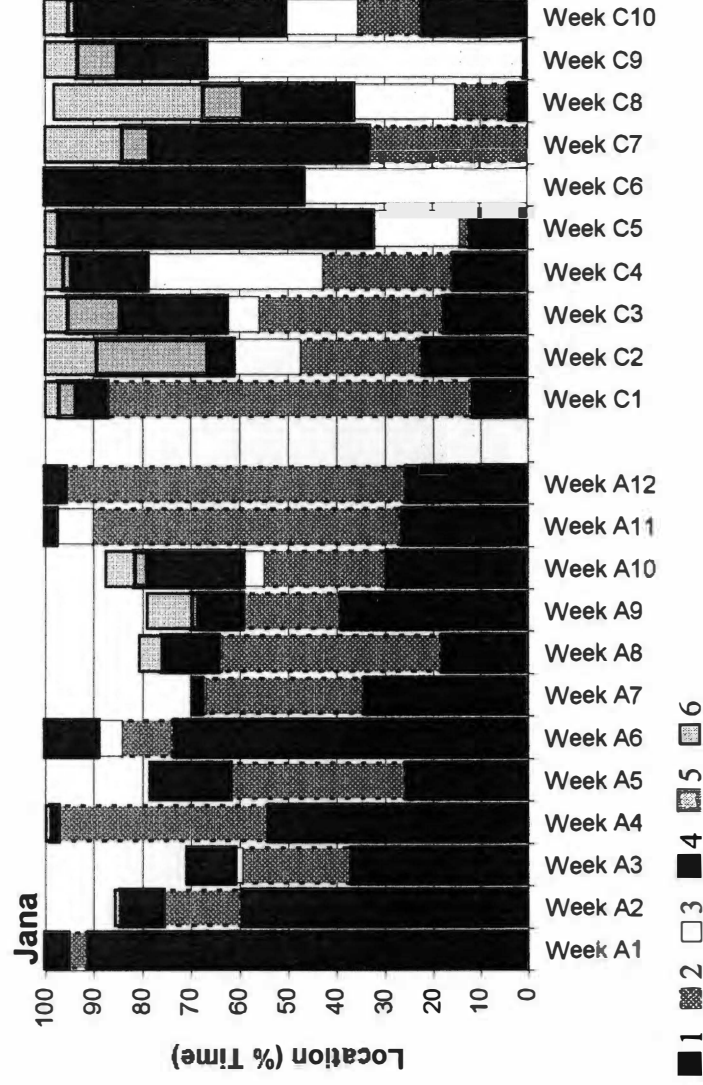


Figure 22. Average Weekly percentage of time Jana spends in each location. The Majority of Observations in Weeks labeled; A are in location 1, and C are in location 4 or 5.

Indicating that she was utilizing more of the space available and exploring her new environment.

Mamie, Figure 23. spent a lot of time with Jana near the water source in the original enclosure, but she tended to use more of the enclosure overall. In the new enclosure she spent the majority of her time near the barn. It is difficult to assess whether she is exploring the new environment as we could for Jana.

Ellie, Figure 24, spent a lot of time near the water in the baseline enclosure. This was because she backed into a corner to put the water hole between herself and the other cows. In the new enclosure there is no good hiding spots so she moves around more. It is possible that she is also exploring her environment in a manner similar to Jana.

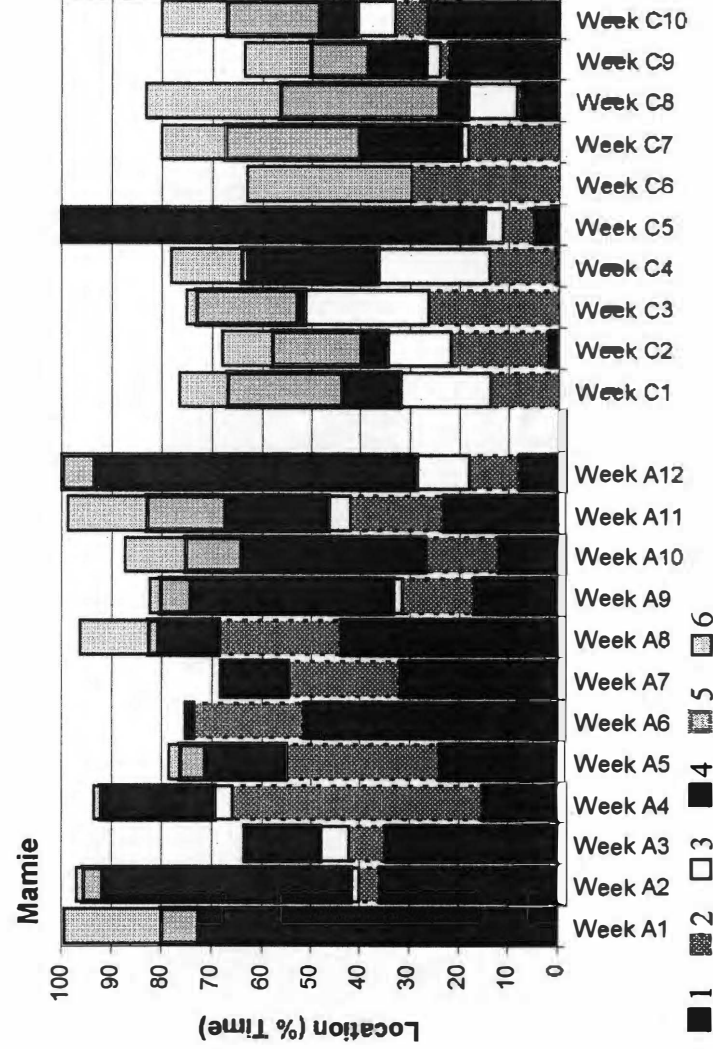


Figure 23. Average Weekly percentage of time Mamie spends in each location. The Majority of Observations in Weeks labeled; A are in location 1, and C are in location 4 or 5.

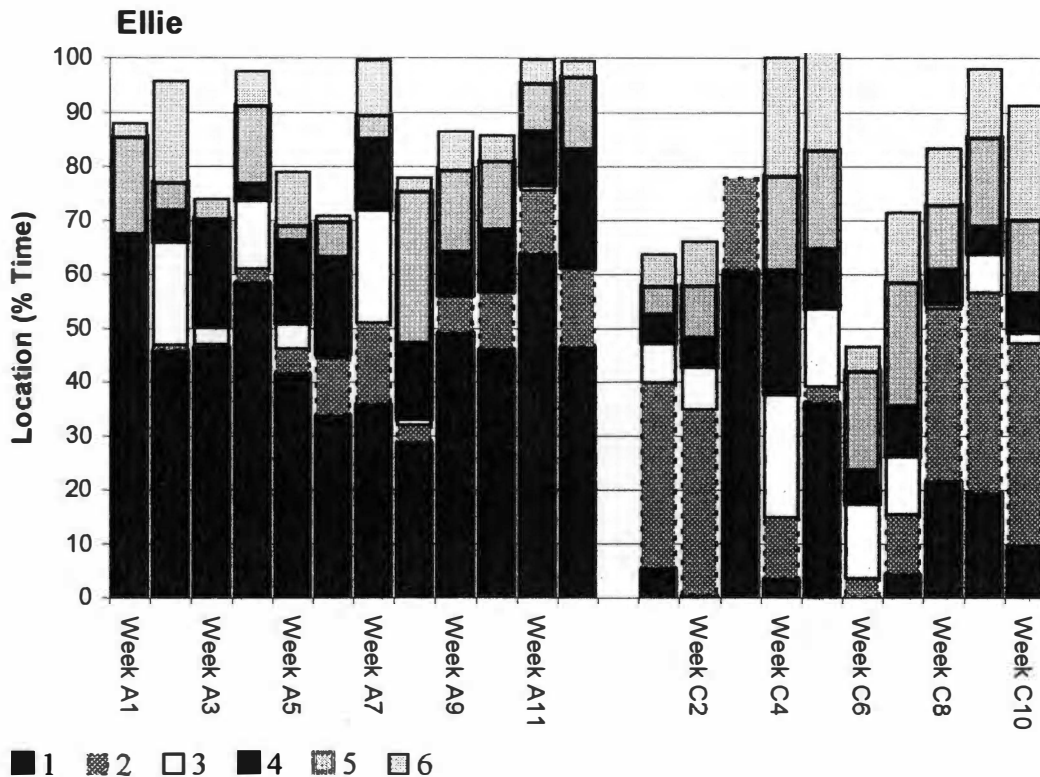


Figure 24. Average Weekly percentage of time Ellie spends in each location. The Majority of Observations in Weeks labeled; A are in location 1, and C are in location 4 or 5.

Social Behaviors

Proximity was a gross behavioral measure of elephant sociality. The assumption is that by measuring the percentage of time that the elephants are in close spatial proximity to one another, we are measuring all social behavior that occurs during that period whether it was positive or negative. Animals that spend a large percentage of time in proximity to one another accept one another as a part of the same social grouping.

Jana spent about 15% amount of her time in proximity with Mamie during baseline. As seen in Figure 25, after entering the new yards Jana spent even more of

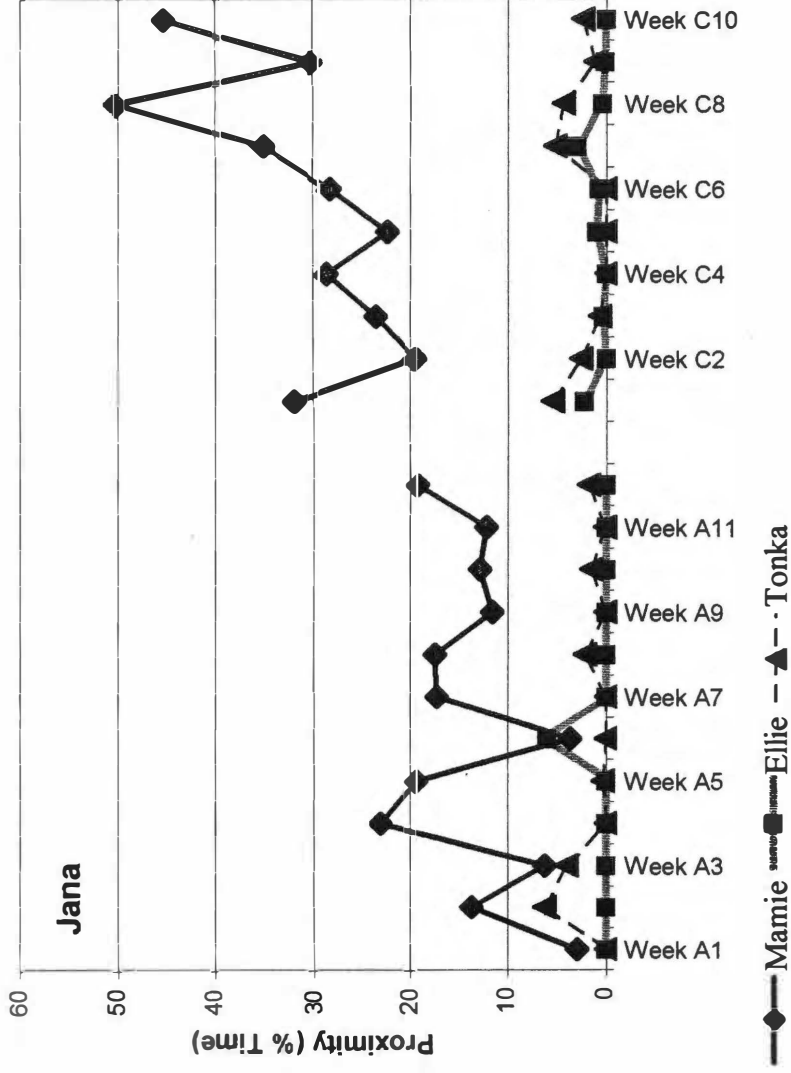


Figure 25. Average Weekly percentage of time Jana spends in spatial proximity to the other elephants individually. The Majority of Observations in Weeks labeled; A are in location 1, and C are in location 4 or 5.

her time in close proximity to Mamie while maintaining baseline levels of interaction with Ellie and Tonka. While in the barn and holding areas, 2 & 3, elephants were kept with Jana and Mamie together in a small enclosure and Tonka and Ellie in isolation; therefore, these areas have been removed from this analysis. A one way ANOVA found that there was a significant increase in the percentage of time Jana spent in close proximity to Mamie, $F(5,308)=7.2$, $P<0.01$, but not any significant change in the time spent in proximity with the other two elephants. Post hoc Dunnett's T tests revealed that the difference was significant between baseline and the new large yard, $m1=14.3$, $m5=35.5$.

Mamie replicates Jana in her social changes. Although, analysis of the average weekly time Mamie spends in proximity to the other elephants, Figure 26, she appears to have more variability of proximity with Jana in the new yards than Jana had with her. However, an analysis of mean percentages of proximity to Jana in each location, $m1=15.1$ $s1=21.2$, $m4=38.8$ $s4=27.5$, $m5=29.5$ $s5=34.5$, reveals that there is an increase in Mamie's percentage of time spent in proximity with Jana. A one way ANOVA found that there was a significant increase in the percentage of time Mamie spent in close proximity to Jana, $F(5,395)=6.6$, $P<0.01$, but not any significant change in the time se spent in proximity with the other two elephants. Post hoc Dunnett's T tests revealed that the difference was significant between baseline and the new large yard.

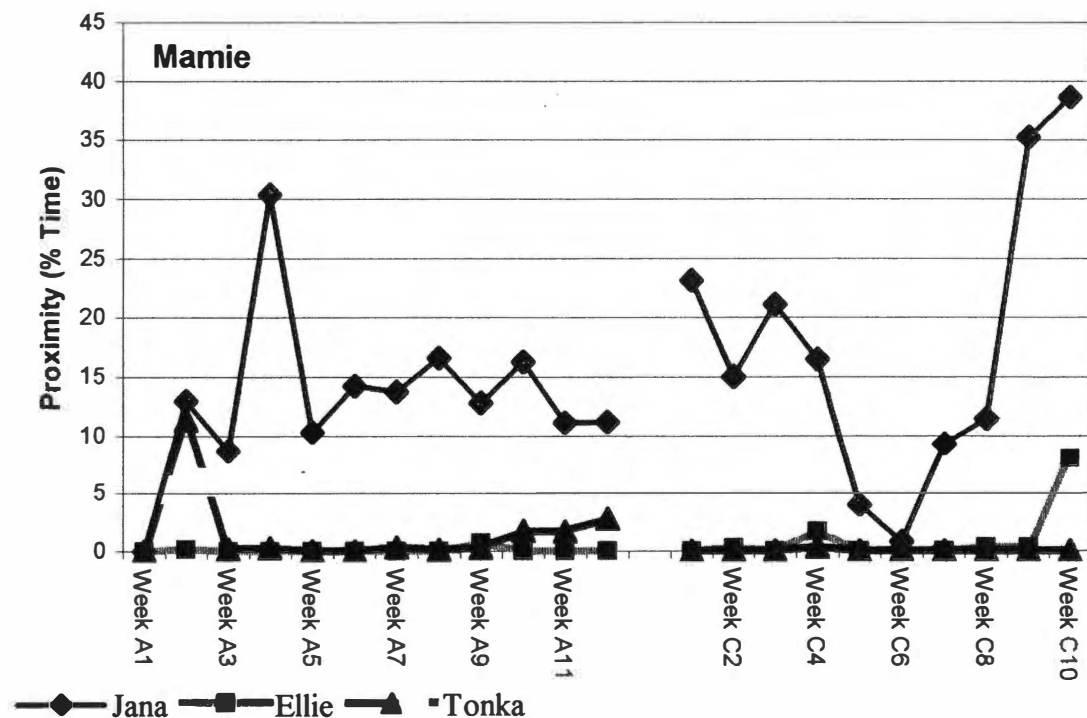


Figure 26. Average Weekly percentage of time Mamie spends in spatial proximity to the other elephants individually. The Majority of Observations in Weeks labeled; A are in location 1, and C are in location 4 or 5.

Ellie spent much less time in social proximity to other animals at baseline than the other cows, proximity Jana $m1=1.6$ $s1=9.3$, with Mamie $m1=0.1$ $s1=0.5$. She had an increase in the amount of time she spent in proximity after translocation, Figure 27. A one way ANOVA found that the only significant increase was Ellie's percentage of time spent in proximity with Tonka, $F(5,308)=6.3$ $p<0.01$. At baseline encounters between Ellie and Tonka were rare $m1=1.22$ $s1=3.6$, but after translocation they were often noted interacting with one another $m5=8.7$ $s5=17.0$. Post Hoc Dunnett's T tests found this increase to be significant. The overall increase can be seen in Figure 28.

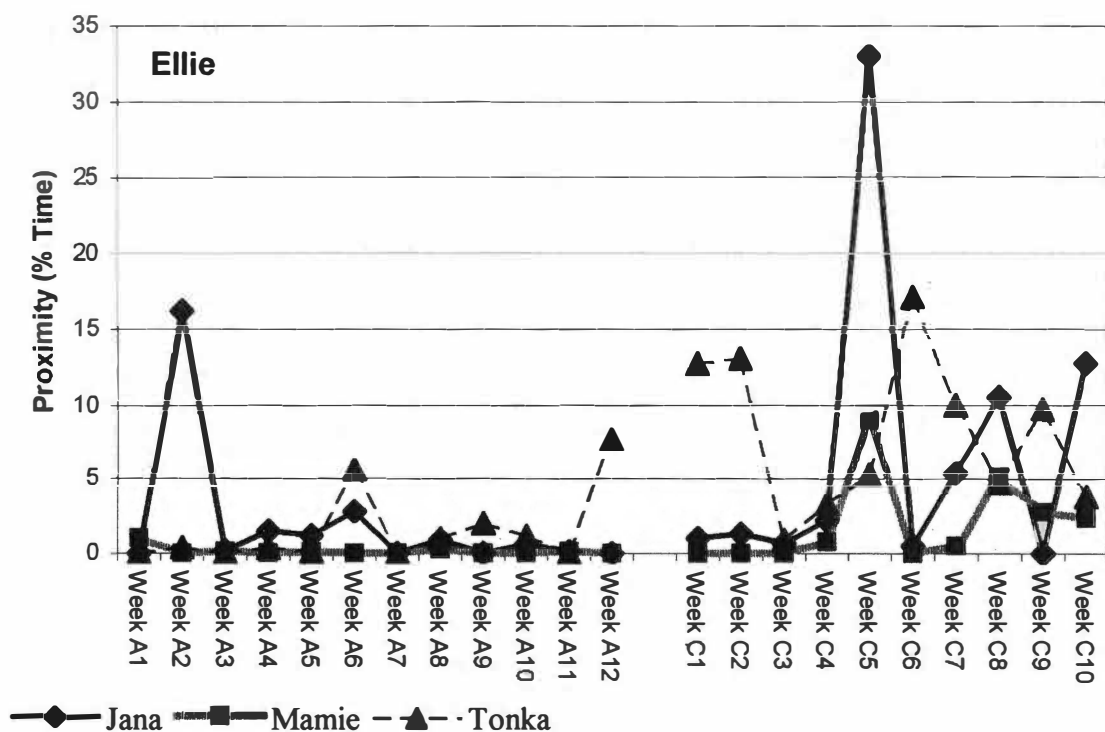


Figure 27. Average Weekly percentage of time Ellie spends in spatial proximity to the other elephants individually. The Majority of Observations in Weeks labeled; A are in location 1, and C are in location 4 or 5.

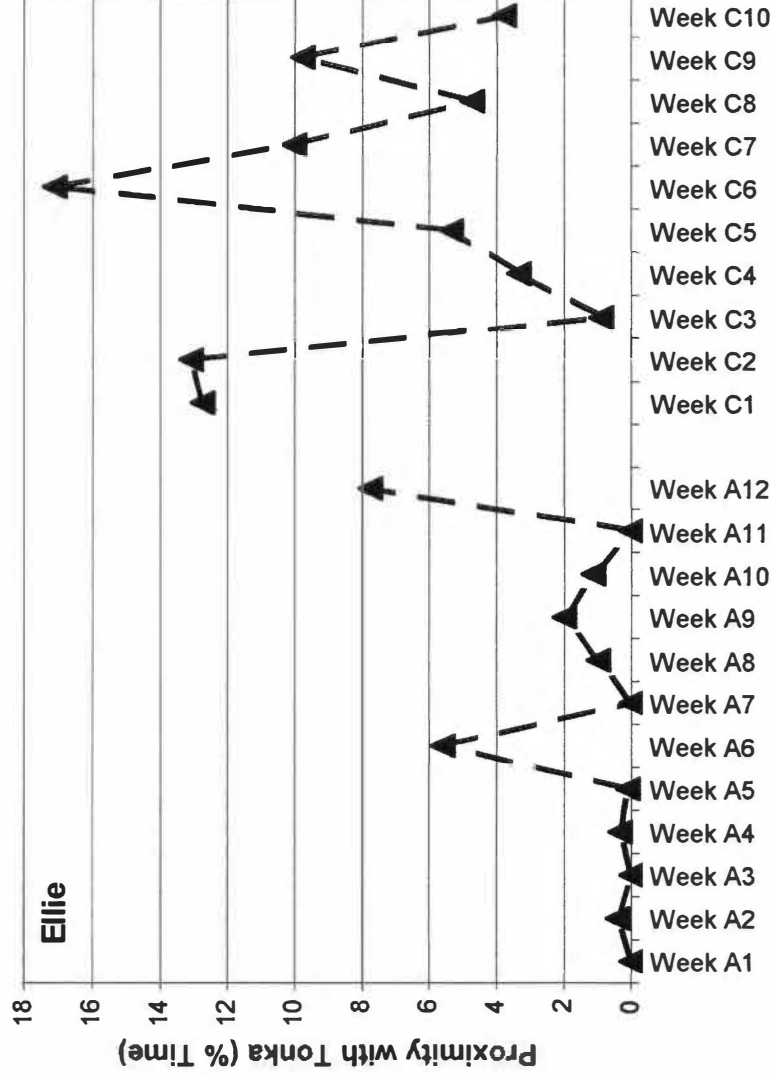


Figure 28. Average Weekly percentage of time Ellie spends in spatial proximity to Tonka. The Majority of Observations in Weeks labeled; A are in location 1, and C are in location 4 or 5.

Analysis of change in Tonka's behavior is not reliable since very little data was collected on him at baseline and all data of him in the new barn was prevented. For this reason Tonka was left out of normal analysis of behavioral change. Nevertheless, by looking at just the average weekly percentages of time Tonka spent in proximity with the cows in the new yard, Figure 29, we can help answer our questions regarding the success of this move. Tonka spends more of his time in proximity with Ellie who is considered the bottom of the social ladder than the other two cows. Tonka spent an average of 8.13 percent of his time with Ellie while in his new yard and only 2.04 percent of time with Jana.

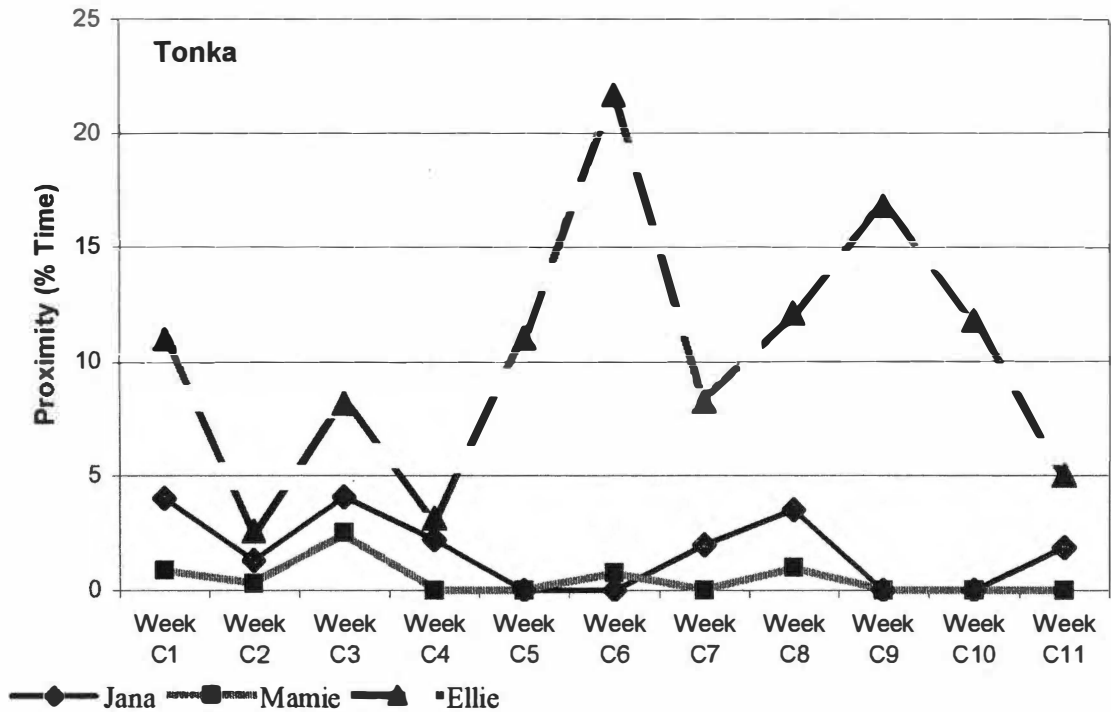


Figure 29. Average Weekly percentage of time Tonka spends in spatial proximity to the other elephants individually. The Majority of Observations in Weeks labeled C are in location 4.

The relationship of the cows did not seem to change significantly after translocation. Jana and Mamie continue to spend time near one another without being near Ellie. There was a decrease in the observed frequency of their contacting one another as they stood in proximity, Figure 30 and 31. This may reflect a decrease in agonistic encounters between the two, or this may just reflect an increase in the amount of space available.

There was also a decrease in the frequency of observed displacements for both animals, Figure 32 and 33. Both animals seem to be displacing each other as well as Ellie less often than in the original enclosure. This could also reflect a decrease in agonistic behavior due to increases in space.

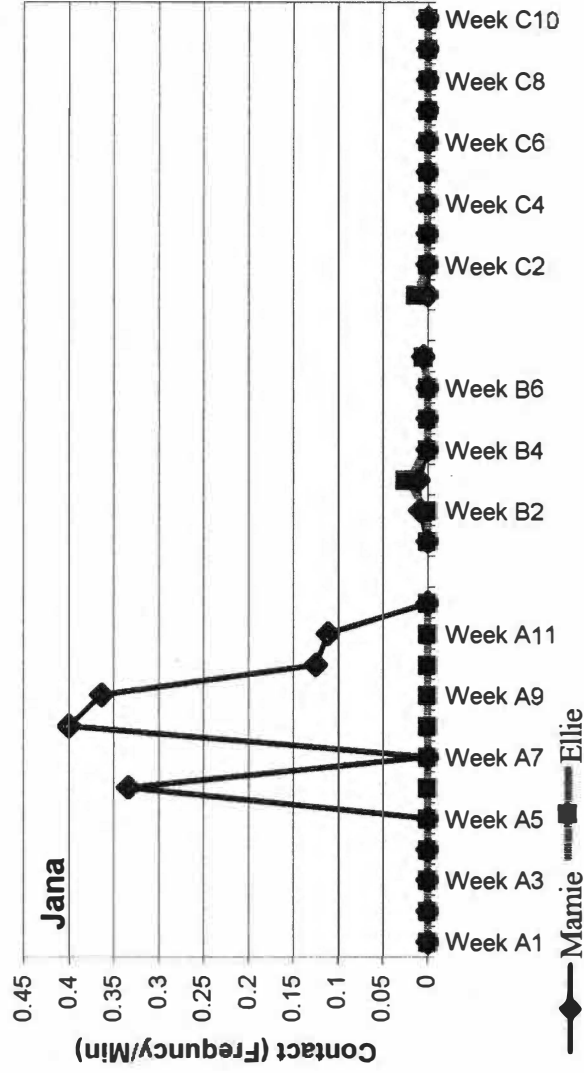


Figure 30. Frequency per minute Jana was observed physically contacting the other elephants individually. The Majority of Observations in Weeks labeled; A are in location 1, B are in location 2,3, or 4, and C are in location 4 or 5.

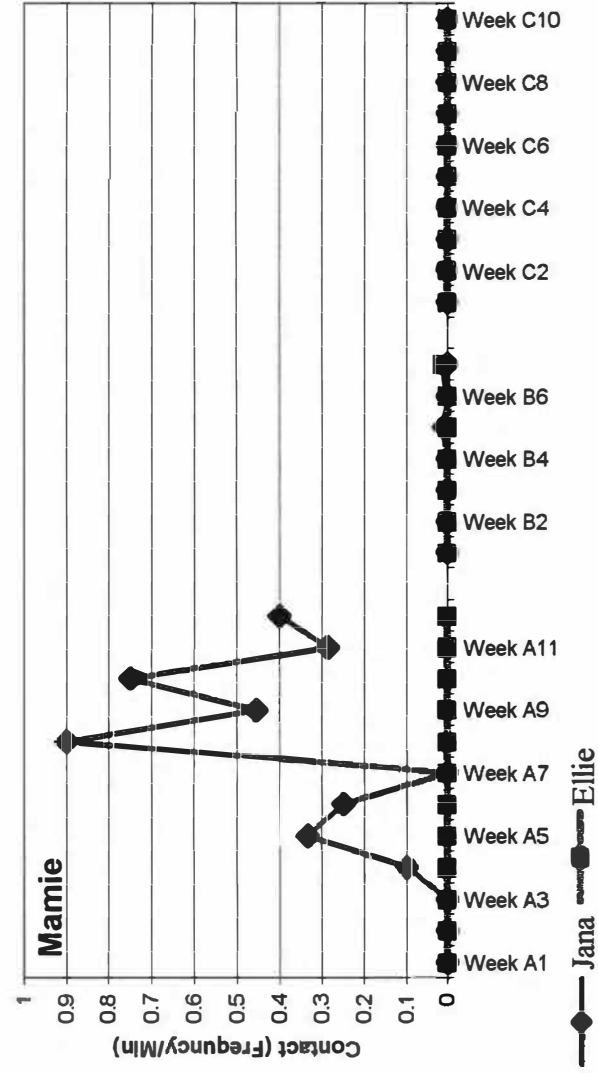


Figure 31. Frequency per minute Mamie was observed physically contacting the other elephants individually. The Majority of Observations in Weeks labeled; A are in location 1, B are in location 2,3, or 4, and C are in location 4 or 5.

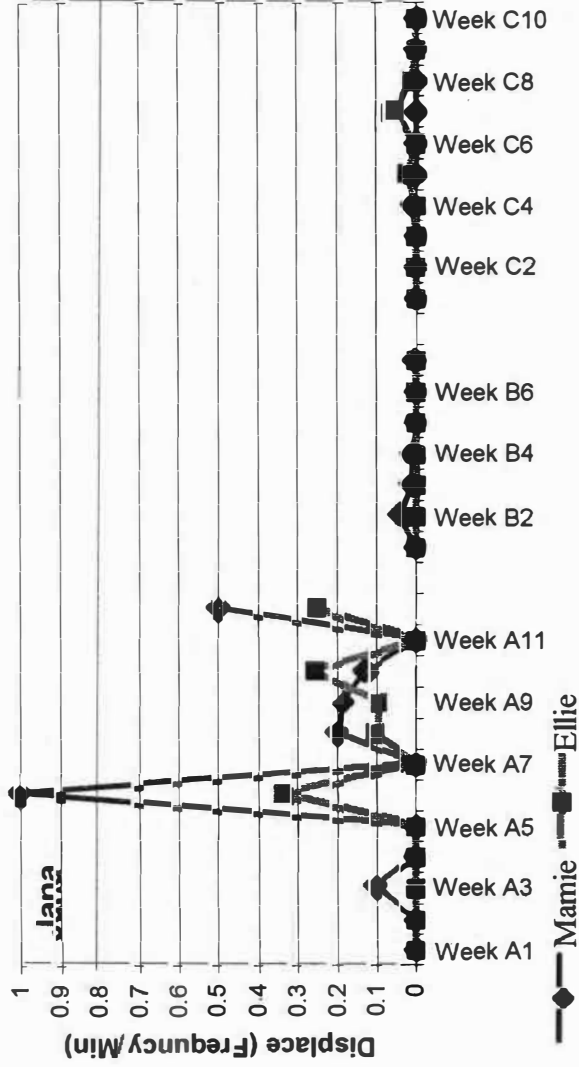


Figure 32. Frequency per minute Jana was observed displacing the other elephants individually. The Majority of Observations in Weeks labeled; A are in location 1, B are in location 2,3, or 4, and C are in location 4 or 5.

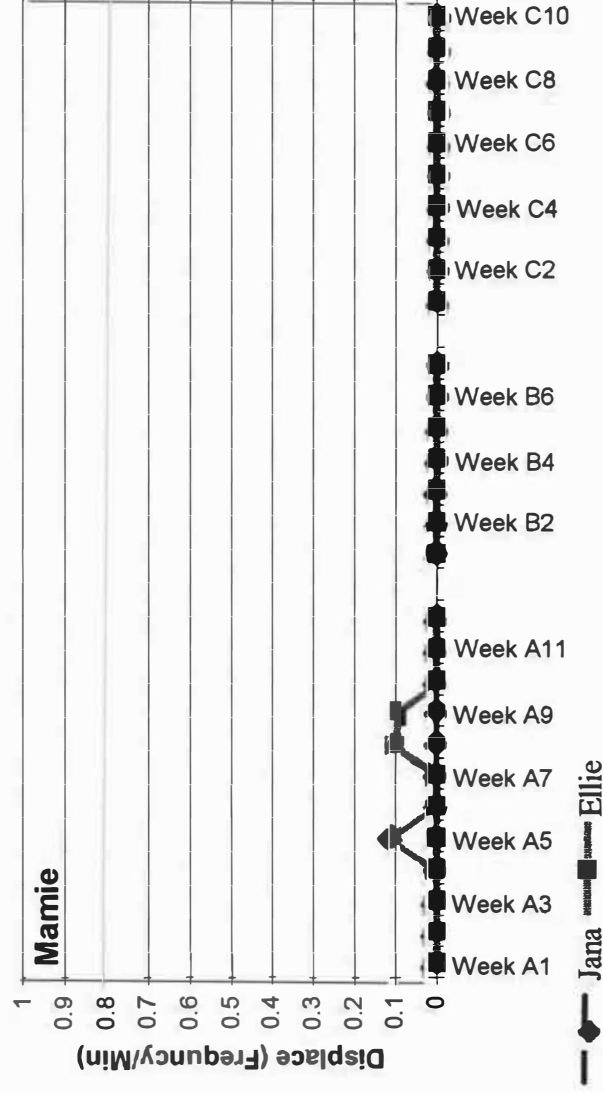


Figure 33. Frequency per minute Mamie was observed displacing the other elephants individually. The Majority of Observations in Weeks labeled; A are in location 1, B are in location 2,3, or 4, and C are in location 4 or 5.

There was no observed change by Ellie in either of these behaviors, and she was never observed displacing another elephant. Furthermore she continues to avoid the other elephants on a regular basis. In Figure 34, there was a noted large increase in her avoidance of the other cow elephants several weeks after they were allowed into the large yard. This increase decreased over time, although, the keepers began to isolate Ellie from the other cows near the end of the study possibly in reaction to the increase in her avoidance. Neither Jana nor Mammie avoid other elephants to any significant level.

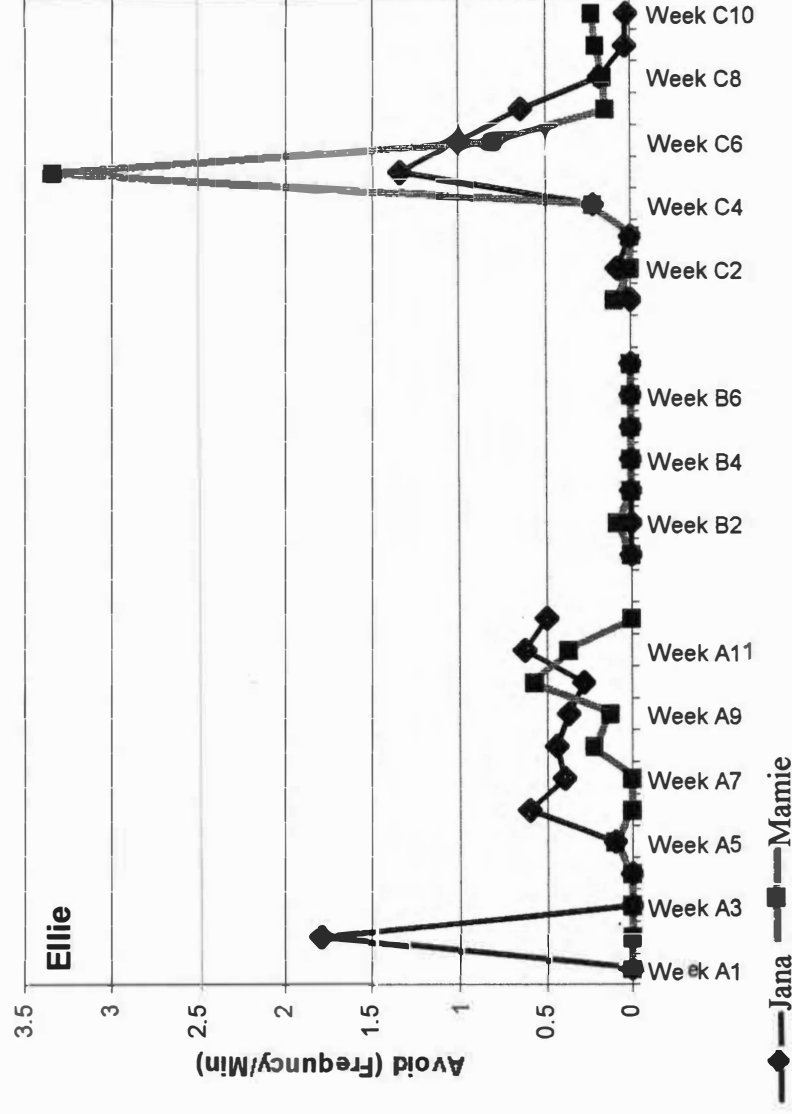


Figure 34. Frequency per minute Ellie was observed avoiding the other elephants individually. The Majority of Observations in Weeks labeled; A are in location 1, B are in location 2,3, or 4, and C are in location 4 or 5.

One of the most interesting social changes after translocation was the change in social interaction with Tonka. Combining the average percentages of time the cows spent in spatial proximity with Tonka into one figure, Figure 35, we looked at how the interactions between the cows and the bull changed after the move. Jana increased the amount of time she was near Tonka. Mamie almost completely stopped being in proximity with him. Ellie increased the amount of time she spent in proximity with Tonka dramatically. She spent more time in proximity with Tonka than either of the other cows after the move occurred.

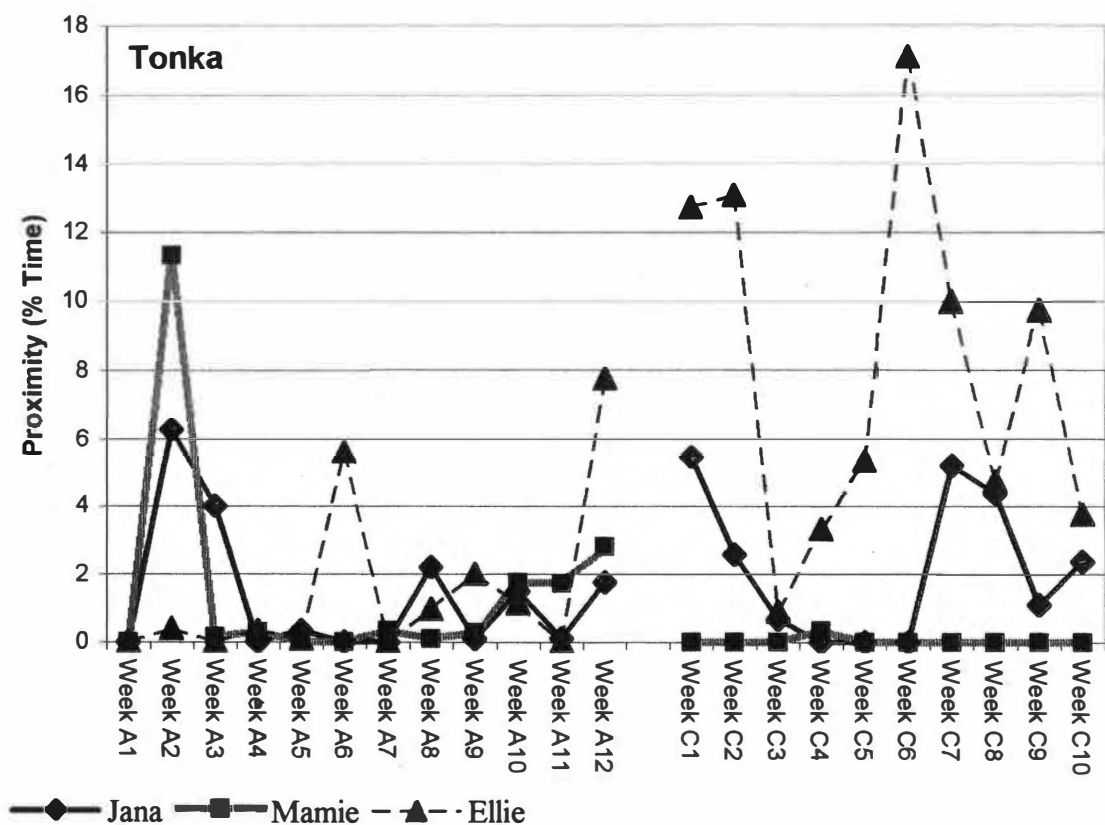


Figure 35. Average weekly percentage of time the cows were observed in spatial proximity to Tonka. The majority of observations in weeks labeled; A are in location 1, and C are in location 4 or 5.

Trunk touching is a common elephant social activity. This group of elephants did not engage in trunk touching with regularity making it a very rare event. Combining all forms of trunk touching allows us to examine changes in interactions with Tonka to support the proximity data. Jana, Figure 36, used her trunk to interact with Tonka over the fence in the original enclosure but stopped this form of interaction after moving to the new enclosure where he was more accessible. Mamie was only observed touching Tonka with her trunk once for the entire study. She held his trunk on this occasion. Ellie, Figure 37, engaged in this behavior the most at baseline and continues to perform it after translocation.

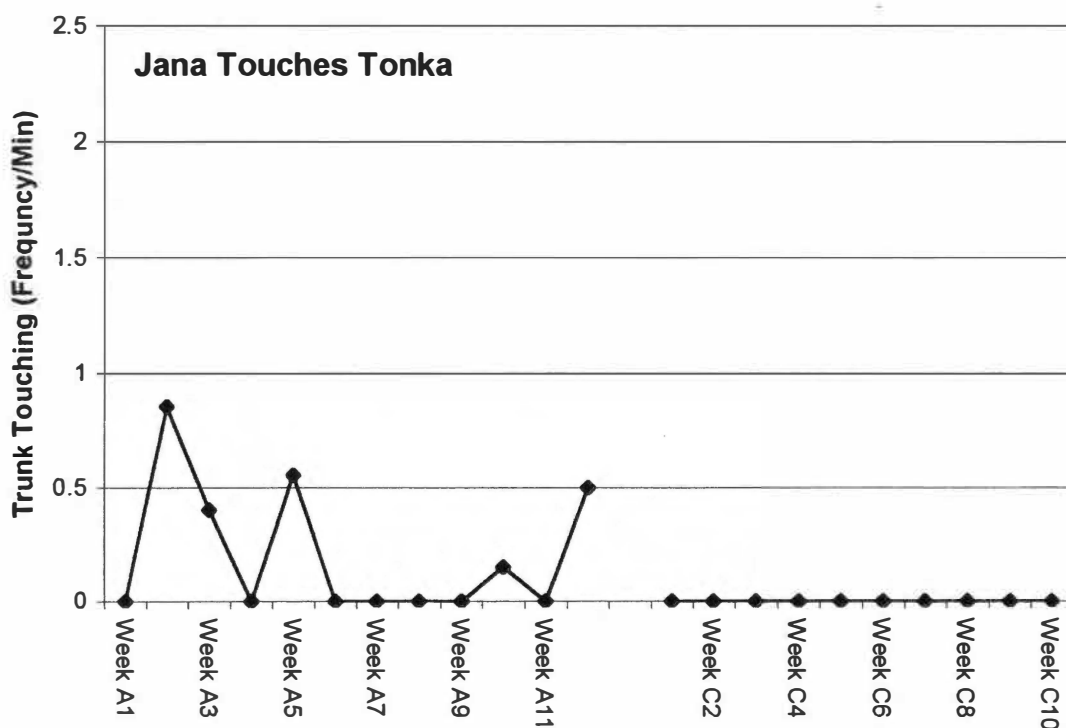


Figure 36. Frequency per minute Jana was observed touching Tonka with her trunk. The Majority of Observations in Weeks labeled; A are in location 1, and C are in location 4 or 5.

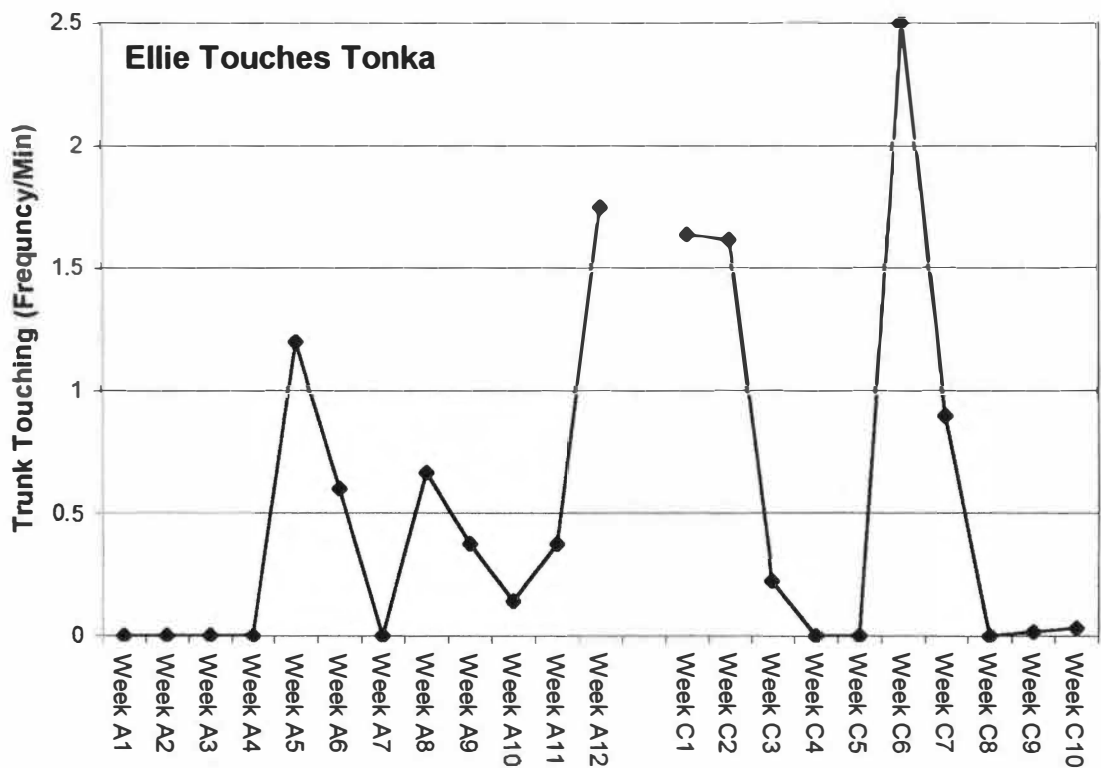


Figure 37. Frequency per minute Ellie was observed touching Tonka with her trunk. The Majority of Observations in Weeks labeled; A are in location 1, and C are in location 4 or 5.

Analysis of Tonka's behavior was difficult due to limited baseline data.

However, trunk touching like proximity, Figure 29, support the cows observed interactions with him. Tonka touches Ellie more than the other cows, Figure 38.

Tonka only touched Jana with his trunk for any significant amount of time during one week of eleven observed after translocation. The interaction with cows is different as well. Tonka interacts with Ellie primarily by touching her genitals and body, Figure 39. While most of the interaction with Jana is just touching her body and not her genitals, Figure 40. A summary of all-significant behavioral changes with Post hoc Dunnetts T tests are given in Table 1.

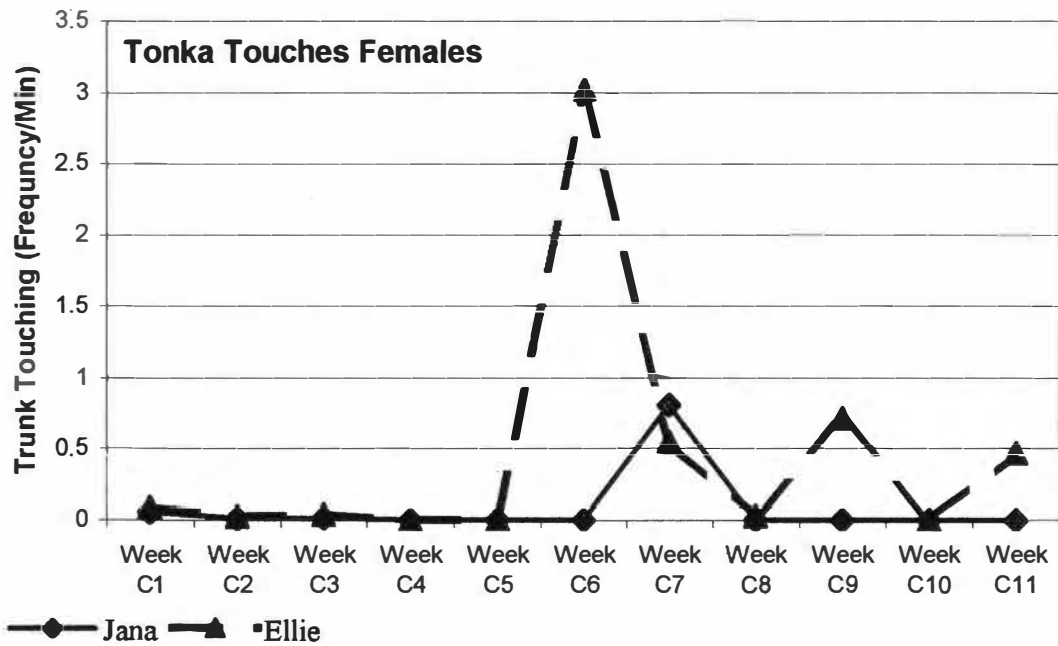


Figure 38. Frequency per minute Tonka was observed touching the cows with his trunk. The Majority of Observations in Weeks labeled C are in location 4 or 5.

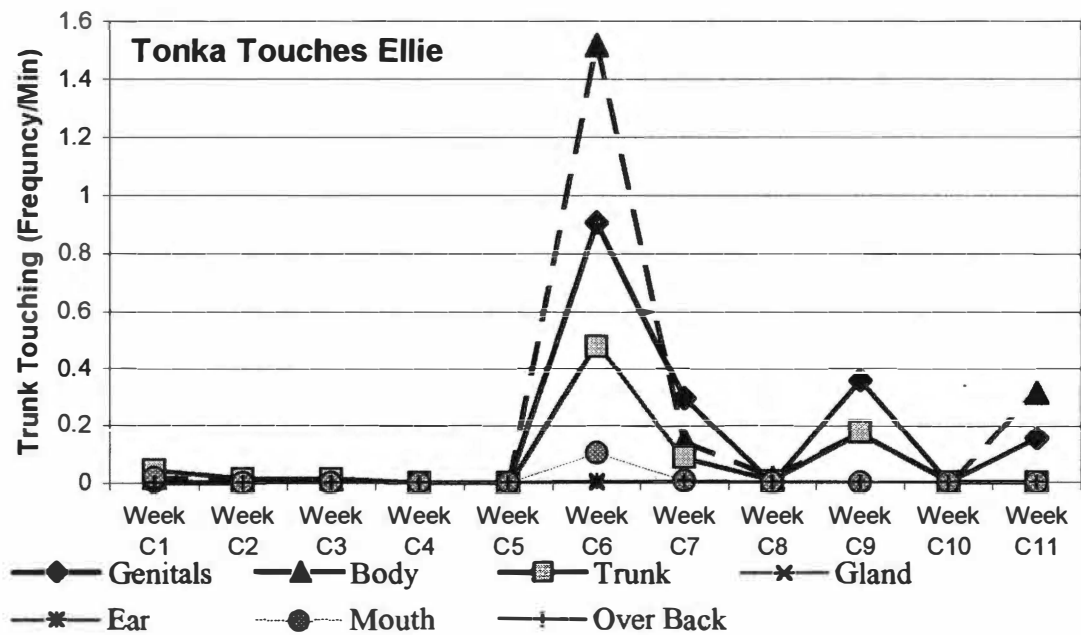


Figure 39. Frequency per minute Tonka was observed touching Ellie with his trunk. The Majority of Observations in Weeks labeled C are in location 4 or 5.

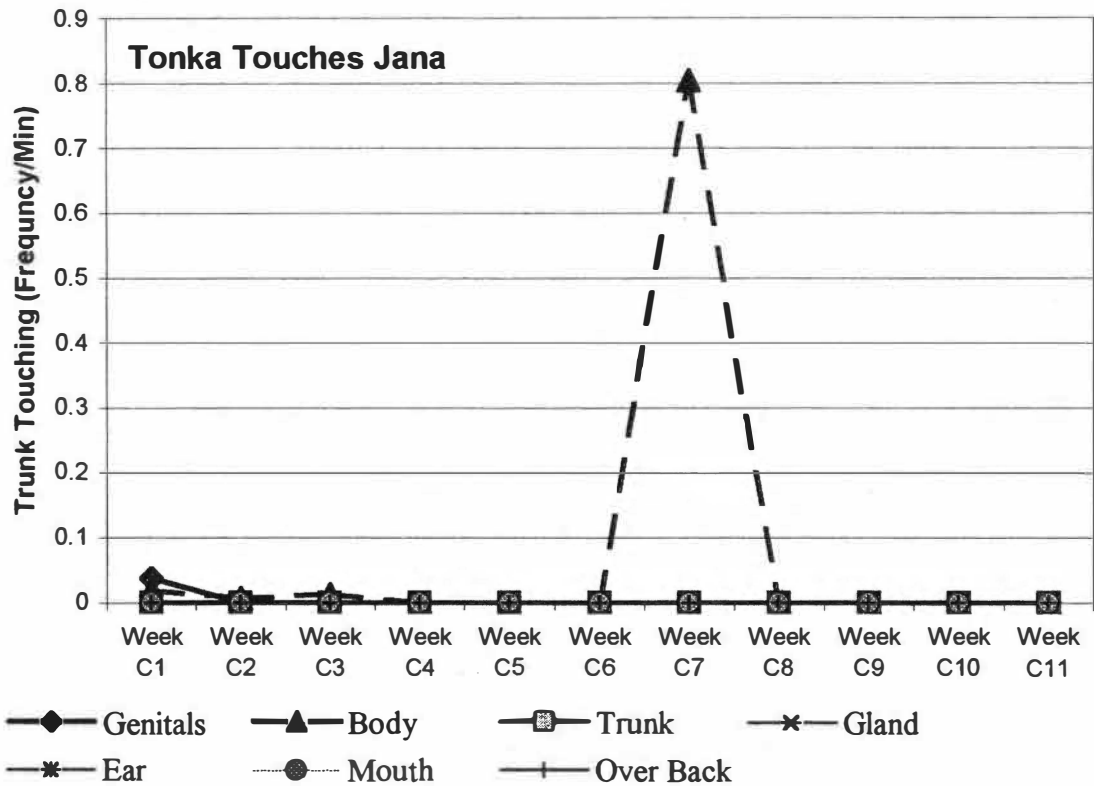


Figure 40. Frequency per minute Tonka was observed touching Jana with his trunk. The Majority of Observations in Weeks labeled C are in location 4.

CHAPTER IV

DISCUSSION

Our hypotheses about changes in African elephant behavior were supported and important observations about these changes have been made. In discussing support of these hypotheses I go back to the original series of research questions we proposed.

Gross Behavioral Changes

What are the behavioral changes that occur when a captive elephant is moved from one environment to another? There were clear changes in some elephant's behaviors after translocation. Some of the changes, like changes in resting and movement were temporary, returning to the original observed levels after a few weeks of recovery. The temporary behavioral changes were deduced to be signs of acute stress and exploratory behavior of the new environment. The changes all returned to levels observed in the original enclosure by the fourth week of observation. Assuming these behavioral changes were signs of stress than we can estimate that the acute stress of translocation lasts about 4-6 weeks.

Feeding also had a similar change; there was a significant decrease in feeding inside the barn for Jana and Mamie. Decreases in feeding behavior were a possible indicator in stress or perhaps due to being prevented to feed by other elephants. However, an interview with the keepers revealed that this behavioral change was caused by a reduction in available food during those weeks because they were wasting a lot and had been put on diets (Personal communication, June 26, 2003).

Other behavioral changes seemed to be relatively permanent, or at least had not returned to baseline after 10 weeks of observation in the new yards. A number of these changes were related to the social standings.

The dominant cow, Jana, changed the least. Jana had a significant reduction in stereotypic swaying behavior and replaced that time with a significant increase in other activities such as sand bathing. Jana's use of space in the enclosure changed slightly in that she tended to use more of the new larger yard than she had the old yard. It would be interesting to see if she will begin to settle near the barn entrance again and defend a territory as she did in the original enclosure.

The beta cow, Mamie, had a significant increase in the amount of time she spent standing. She also had a significant increase in other activities such as sand bathing. Observers noted that Mamie spent large amounts of time throwing all sort of things on her back, including rocks and gravel, which made her glitter in the sunlight. Mamie had no corresponding statistically significant decreases in state behaviors but this time probably is reflected in a non-significant decrease in sleeping, feeding, and foraging.

The least dominant cow, Ellie, had the most significant enduring behavioral changes. Ellie's standing behavior returned to baseline levels in the new yard indicating the reduction was only stress related but unlike the other two cows her feeding behavior and foraging behavior were observed to be half of what they were at baseline and less than half the time that the two other cows spent performing these activities. This decrease was significant and there was no evidence of an increase over the course of the study. Since the other two cows did not share this reduction

after being let out of the new barn it should not be due to the reduction in food available by the diet introduced inside the barn. Analysis of notes taken by observers indicated that her reduction in eating was due to increased social pressure from the other cows who continued the food displacement activities they had done in the original environment. Displacements had decreased but the effect on Ellie's feeding behavior seems to have increased. One possibility is that this is due to an interaction of the normal social stress with the translocation stress that in an additive or multiplicative fashion lead to large stress reactions such as this reduction in feeding and foraging. Like the other cows Ellie had increased other activities such as sand bathing. Unlike the other cows Ellie had a significant increase in a stereotypic swaying behavior. While she rarely performed this behavior at baseline and keepers actively attempted to train her to not perform this behavior she increased to an average of 13.9% of her time in the new enclosure was spent swaying.

In my analysis, it has been assumed that the elephant stereotypies were related to stress and indicative of decreased psychological well being. The first assumption is an agreed upon one (Garner & Mason, 2002; Lawrence & Rushen 1993) in that it is generally assumed that stereotypies arise in response to stress. Some special cases have been examined in which this assumption was challenged (Mason, 1991). Swaying in elephants was found in the wild to be a stress reaction to the presence of humans and when the elephants get used to a human observer the thought to be common behavior of swaying stops (Douglas-Hamilton, 1975). Current studies of stereotypies in Asian elephants found a strong correlation between the behaviors and

cortisol levels (Schmid, Heistermann, Ganslosser, & Hodges, 2001). It seems a safe assumption that these behaviors are a behavioral stress reaction.

Stress Related Behaviors

How long after a move do the elephants exhibit signs of stress from being in the new environment? We hypothesized that stress was related to enclosure size leading to decreased stereotypy and increases in social behavior. In Jana's case the data support this hypothesis. Jana had a significant decrease in swaying in the new yard, which was almost twice as large as the original yard. Unlike the findings of Lester (1997) Jana did not have an increase in this behavior while in the smaller barn enclosures which was likely due to the difference in the normal routine for elephants from Lester's Chimpanzees. Elephants are placed in smaller barn enclosures and on leg chains regularly throughout their lives. The smaller enclosures Lester studied may have been more out of the ordinary meaning that the stress of smaller enclosures is more due to their novelty than spatial crowding.

As hypothesized, Jana had an increase in social behaviors with Mamie in the larger yard over baseline. There was not an increase in socialization with Ellie or Tonka, but they are not a close part of Jana's normal social grouping. Cows and adult bull elephants do not normally interact, and Ellie was not ever treated as a close member of Jana's herd. Mamie did not engage in a specific stereotypy but she also had an increase in socialization with Jana.

Ellie had an increase in socialization, not with the other cows, but with the bull Tonka. Data suggest that Ellie was a social grouping to herself. Her background

of being raised without other elephants, and her non-acceptance by the other cows makes her a lone female. While the other cows continue to push her away Ellie still had the hypothesized increase in socialization with the only other elephant available. Tonka was in a similar situation. Tonka was the only bull, with no other bulls for a bachelor herd, so he increased socialization with Ellie. Ellie also supported our hypothesis regarding stereotypy. Ellie was observed performing Corprophagia and was expected to have a decrease in the new large yard. While this behavior was rare, there was an increase in this behavior inside the barn and small holding areas. It is more difficult in this case to make inferences about enclosure size or novelty; however, there was a definite stress related reaction to the initial translocation that returned to baseline after 4-6 weeks.

We observed other stress related behavior patterns with similar time frames. While no significant change in resting behavior was found it is important to make note of an anecdotal observation. Observers watching the elephants in the first weeks after being allowed into the new barn found noticeable increases in resting. The cows were described as exhausted. Keepers made note that they had been very actively objecting to their new habitat and were up all night tearing up the floor and flinging fecal matter. Therefore during the normal daytime viewing hours they were simply worn out with exhaustion and the two cows rarely seen resting at baseline were observed sleeping in the new barn during this short time period. All three cows had an increase in daytime sleeping after translocation. For Jana and Mamie this increase began to return to baseline levels after the observed 4-6 week period. Ellie reduced this behavior after that period but continued to have an increase in daytime sleeping

until the elephants were moved outside on a more permanent basis 8-10 weeks after translocation.

Jana and Mamie had increases in moving behavior for a short period after translocation as well. This increase coincides with the increase in resting and the decrease in feeding indicating high stress. This increase was interesting because they had very little room to move inside the 100m² barn enclosure. Inside this small area together this increase represents pacing and other small movements. The increase in movement returned to the original observed levels faster than other stress indicators, around 2-4 weeks after translocation.

Urination and defecation were the behaviors added to the ethogram to measure acute stress responses. Urination and defecation are good behavioral markers for stress in any mammal. As stress increases these behaviors tend to increase in frequency. After the initial translocation elephant keepers reported a large increase in defecation. Mamie had a large increase in these behaviors after translocation which returned to baseline after 4-6 weeks. Ellie has a similar reaction that was twice as large of an increase during its peak at the 4th week of observation after translocation. These increases were not observed after translocation from the new barn and holding area to either of the new yards. This indicated that the move outside to the new yards had much less acute stress than the initial translocation. Therefore the multiple stages of translocation may have allowed less injurious behaviors, such as those described by Heidiger (1969), to occur as a result of this stress. Moving the elephants in stages allowed all the stress related behaviors of the initial translocation to occur in the protective environment of the barn and not to

occur in the spacious and more hazardous new yard. The Knoxville zookeepers in this situation successfully avoided the hazards Heidiger (1969) warned of.

Social Changes

How does the move affect their social structure? The social behaviors of the cows changed after translocation but the actual social relationships remained the same. Buss (1961) suggested that elephants assemble in family units of closely related cows and their offspring. It is difficult to replicate this wild social unit in captivity as elephants are purchased by zoos one at a time, and captive birth of African elephants is very rare (Brown, 2000; Olsen & Wiese, 2000) which creates unrelated social groups in captivity. In the case of the Knoxville Zoo population, Jana and Mamie shared three successful years together before the study began. Zookeepers described their relationship as sisters. Their baseline social behaviors include spending 14-15% of their time in close proximity to one another and sometimes touching each other. We concluded that they were a solid social grouping that mimics a wild female herd. Ellie on the other hand was not so successful integrating as part of the family. Ellie was raised alone in captivity and observers noted Ellie actively sought keeper and patron attention. While keepers attempted to integrate her into the group, she did not exhibit signs of acceptance at baseline. She spent less than 2% of her time in proximity with either of the other cows and actively avoided them around once every 5 minutes. When Jana or Mamie moved, Ellie moved in the opposite direction.

It is possible to have separate social groupings in natural herds. Kinship groups (Douglas-Hamilton, 1975) of multiple families under multiple matriarchs will often come together when the environment necessitates it (1973). Moss (1977) who found that family units at Amboseli National Park sometimes split up into sub-units during the dry season and after a calf birth but soon come together again. The data suggest that Ellie was a sub unit of the female herd. Jana and Mamie tolerated Ellie because they had to be in the same enclosure, but they stole her food and chased her around the enclosure. Therefore when the enclosure got larger we hypothesized that if these were different groups, then when given the opportunity the groups would spend less time near each another.

With such a low level of interaction before the move there was not a significant decrease in interaction between Ellie and the other cows. While Jana and Mamie had significant increases in their social relations there was no significant increase in the relation between Ellie and the other cows. Jana and Mamie decreased the amount of physical contact they made with one another as well as the amount of displacements they performed. Contact reduction includes in this case aggressive behaviors towards one another. Reduced displacement not only is a reduction in taking things from Ellie but also each other. Reduce displacement of Ellie reflects that larger space allows these cows to accept her presence more readily and that resources are perceived as being more abundant. Ellie continued to avoid the other cows and otherwise remains a social grouping of her own.

How does an increase in availability of a bull elephant affect the behaviors of a group of cows who previously had limited contact with the bull? From the Zoo

perspective the major benefit of the new yards is the availability of Tonka to interact with the cows in a semi-protected environment. The goal was to increase interaction between all of the cows and Tonka to promote the possibility of successful mating. For Ellie this was a major success. She spent significantly more time in spatial proximity with Tonka after translocation and is now the elephant Tonka is observed to spend the highest percentage of his time with. She also continued to touch Tonka with her trunk. Tonka touches her as well and importantly he has been observed exploring her genitals to sense if she is ready to mate. This implies that these two elephants given time may have improved their chances of captive breeding.

Mamie was not as successful in attempts to socialize her with Tonka. She was observed in proximity with Tonka very little before and after translocation. A lack of interest by Mamie is not surprising. Mamie ranged from 38-40 years old during the study, which does not mean she is beyond breeding capability. Sikes (1971) notes that it is not unusual to see a great-great-grandmother as herd matriarch with a tiny calf at her own foot. At 40 Mamie would classify as a senior adult eligible for being a leader with a life expectancy of around 80 years. In this case however despite being the largest cow Mamie is not the Matriarch of her small herd. I hypothesize that it is her inexperience and deferral to Jana that led to Mamie's lack of interest in Tonka at this time.

Jana's reactions to Tonka after translocation were unexpected and disappointing. While she became more social with him by increasing the amount of time she spent in proximity with him she was no longer observed touching him with her trunk in any way. Tonka was only observed touching Jana on one week out of

eleven and then was only observed touching her body and not her genitals. So Jana had increased socialization with the bull with decreased sexual interests. This was unfortunate as Jana was the only cow of the three to have ever successfully bred with Tonka before. Discussing her behavior with keepers led us to find that the hormonal monitoring the keepers perform revealed that Jana ceased sexually cycling after translocation. We ran into a similar problem in a group of translocated baboons *Papio Hamadryas* a number of years earlier (Smith, Unpublished Data). The female baboons social structure changed 3 years after translocation because the larger female began to cycle again for the first time since being moved. According to keepers this is a common occurrence after translocation and the females sometimes do not recover the lost sexual ability. A lack of published studies within the zoo population needs to soon be rectified. This claimed common occurrence should be considered in breeding plans such as moving African elephant cows to different zoos to attempt breeding in other places. The translocation to the bull may be preventing successful breeding.

Translocation Success

Are these elephants in a state of enhanced psychological well being and better off due to their new environment, and was it worth the resources the Zoo put into the creation of the environment and translocation of the animals to it? Animals have been found to be more successful in larger, softer more naturalistic zoo environments (Clarke et al., 1982). Translocation is a stressful event (Massot et al., 1994) and a successful translocation will attempt to reduce this stress to prevent mortality (Letty et al., 2000). The elephants in our study exhibited signs of stress, which appeared to

last from 4-6 weeks in the barn, and these stress related behaviors returned to pretranslocation levels in the new yard. Keepers at the Knoxville Zoo utilized a soft release design similar to ones utilized in mammals in the wild (Saltz & Rubenstein, 1995; Haquee & Smith 1996; Letty et al., 2000) to decrease the stress. The reduction in stress before release into the final yard indicates this method was successful.

Elephants exhibit signs of reduced stress from their baseline location through increased socialization and decreased stereotypy. Assuming a relationship between psychological well being and stereotypy is more difficult than assuming a relationship with stress. Georgia Mason (in Lawrence and Rushen, 1993) identified that one of the major problems in identifying a relationship between stereotypy and well being is that, the definition and classification of stereotypies are heterogeneous. Despite contrary several counter arguments along this line Duncan, Rushen and Lawrence (in Lawrence and Rushen, 1993) conclude that one way or the other steps should be taken in animal welfare to reduce stereotypies.

All the animals increased the amount of other activities that were uncommon in the original location such as sand bathing. There was an increase in interactions with the bull Tonka, and in one occurrence there seems to be an increase in sexual related behaviors. All together these elephants appear to be in an improved state. Taken as a whole the data suggest that these four elephants are better off and have enhanced psychological well being in their new enclosure than their previous one.

In future elephants moves in zoo I strongly recommend utilizing this step wise translocation design. I suggest examining the cessation of sexual cycling and the variables that may cause it. Larger space has greatly improved these animals well

being as indicated by their behavior so I also suggest examining overcrowding as a possible factor in the low success rate of captive African elephant breeding.

LIST OF REFERENCES

Brown, J. L. (2000). Introduction to the special issue on elephant biology. Zoo Biology, 19, 297-298.

Buss, I. O. (1961). Some observations of food habits and behavior of the African elephant. Journal of Wildlife Management, 25, 131-148.

Clarke, A. S., Juno, C. J., & Maple T. L. (1982). Behavioral effects of a change in the physical environment: a pilot study of captive chimpanzees. Zoo Biology, 1, 371-380.

Douglas-Hamilton I. (1973). On the ecology and behavior of the lake manyara elephants. East African Wildlife Journal, 11, 401-403.

Douglas-Hamilton I. & Douglas-Hamilton O. (1975). Among the Elephants. New York: The Viking Press.

Eltringham, S. K. (1982). Elephants. Poole: Blandford Press.

Garai, M. E. (1998). Social organization in translocated juvenile African elephants; the dominance hierarchy and an intriguing behaviour. Pachyderm, 25, 42-43.

Garner, J. P., & Mason, G. J. (2002). Evidence for a relationship between cage stereotypes and behavioural disinhibition in laboratory rodents. Behavioural Brain Research, 136, 83-92.

Haque, M. N. & Smith, T. R. (1996). Reintroduction of Arabian sand gazelle *Gazella subgutturosa maricai* in Saudi Arabia. Biological Conservation, 76, 203-207.

Heidiger, H. (1969). Man and Animal in the zoo. New York: Delacorte press.

Kuhme, W. (1962). Ethology of the African Elephant (*Loxodonta Africana* Blumenbach 1997) in captivity. International Zoo Yearbook, 4, 113-121.

Lawrence, A. B., & Rushen J. (1993). Stereotypic Animal Behavior: Fundamentals and Applications to Welfare. Wallingford: CAB International.

Lester, B. A. (1997). Stress due to a forced change on nonhuman primates: With facility review by staff. Masters thesis, University of Houston.

Letty, J., Marchandean, J. C., Clobert, J., & Aubineau, J. (2000). Improving translocation success: an experimental study of anti-stress treatment and release method for wild rabbits. Animal Conservation, 3, 211-219.

Mason, G. J. (1991). Stereotypes: a critical review. Animal Behaviour, 41, 1015-1037.

Massot, M. Clobert, J., Lecomte, J., & Barbault, R. (1994). Incumbent advantage in common lizards and their colonizing ability. Journal of Animal Ecology, 63, 431-440.

Olson, D., & Wiese, R. J. (2000). State of the North American elephant population and projections for the future. Zoo Biology, 19, 311-320.

Ostro, L. E. T., Silver, S. C., Koontz, F. W., Horwich, R. H., & Brockett, R. (2001). Shifts in Social Structure of Black Howler (*Alouatta pigra*) Groups Associated with Natural and Experimental Variation in Population Density. International Journal of Primatology, 22, 733-748.

Saltz, D. & Rubenstein, D. L. (1995). Population dynamics of a reintroduced Asiatic wild ass (*Equus hemionus*) herd. Ecological Applications, 5, 327-335.

Schmid, J., Heistermann, M., Ganslosser, U., & Hodges, J. K. (2001). Introduction of foreign female elephants (*Elephas maximus*) into an existing group: Behavioral reactions and changes in cortisol levels. Animal Welfare, 10, 357-372.

Zucker, N. (1984). Delayed Courtship in the Fiddler Crab *Uca Musica* *Terpsichores*. Animal Behavior, 32, 735-742.

APPENDIX

Table 1. Significant Changes in Behavior and Relevant Statistical Tests

Animal	Behavior	F Test	Dunnetts T Tests (* indicates $p < 0.05$)									
			1-2	1-3	1-4	1-5	2-3	2-4	2-5	3-4	3-5	4-5
Jana	Sway	$F(5,308) = 7.7$			*	*		*	*			
	Feed	$F(5,308) = 4.5$	*						*			
	Other	$F(5,308) = 8.1$				*			*			
	Proximity Mamie	$F(5,308) = 7.2$		*		*						
Mamie	Stand	$F(5,395) = 3.1$		*								
	Sway	$F(5,395) = 3.9$			*			*				
	Feed	$F(5,395) = 4.3$	*									
	Forage	$F(5,395) = 6.8$			*	*		*	*			
	Other	$F(5,395) = 16.4$				*			*		*	
	Proximity Jana	$F(5,395) = 6.6$		*		*						
Ellie	Stand	$F(5,308) = 4.5$		*								
	Sway	$F(5,308) = 12.9$				*			*		*	*
	Feed	$F(5,308) = 7.3$				*			*		*	
	Forage	$F(5,308) = 6.3$				*			*		*	
	Other	$F(5,308) = 5.1$				*						
	Proximity Tonka	$F(5,308) = 6.3$				*			*			
	Avoid	$F(5,308) = 3.4$	*						*			*

VITA

Todd Joseph Smith earned an International Baccalaureate Diploma from St. Petersburg High School in St. Petersburg Florida with a major emphasis in chemistry and theater. From there he earned a B.A. in both Psychology and Biochemistry at Maryville College in Maryville Tennessee. Maryville awarded him an award in excellence in structural chemistry, and the David H. Briggs award for being the top student in psychology. His undergraduate thesis titled "Effects of interaction of caffeine and nicotine on cardiovascular reactivity in borderline hypertensive rats" was published in the Maryville College library as the top thesis in his field.

In pursuing this degree of Doctor of Philosophy at the University of Tennessee in Knoxville, Todd first wrote a preliminary article titled "Plasticity of social structure for captive genetically related *Papio Hamadryas*." This study earned him the 2002 special topics student research award for animal/biological research from the South Eastern Psychological Association. He then wrote an integrative review of literature on African Elephants titled "Future research ideas from field research for captive *Loxodonta Africana*."