

CHANGE IN FEMALE ELEPHANT CALF (*LOXODONTA AFRICANA*) DISTANCE
TO DIFFERENT FAMILY MEMBERS OVER TIME

By

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ABSTRACT

At Reid Park Zoo, Tucson Arizona, spatial distances of the female African elephant calf (*Loxodonta africana*) were compared to the other five members of her herd for 14 weeks. Looking at average distances, maximum distances, and percent change it can be seen overall that the mother was the closest to the calf, then the 4-year old brother, 7-year old brother, father, and aunt. It was concluded that the calf spent most of her time with her mother and younger siblings compared to her father and aunt. Also, the mother and 7-year old brother were the only two members of the herd that had a statistically significant positive increase in distance away from the calf. Trends for the other members of the herd were not statistically significant. Results from this study were compared to P.C. Lee's study on wild elephants, which had similar conclusions in strong mother to calf bonds.

INTRODUCTION

Wild African elephants (*Loxodonta africana*) are a megafauna species that have complex dynamic social interactions (12). Elephant behavior and social structure vary by gender and herd population (12). Adult males tend to be mostly solitary moving between different family units looking for possible mates (12). They occasionally associate with other male bulls by fighting to determine dominance (18). Females tend to travel with a herd of three to twenty-five females and calves where a hierarchy status is created (5, 12). They are found in diverse habitats including tropical forests, savannas, grasslands or woodlands. An African elephant habitat can range from 10 to 70 km² depending on the season and size of herd (12). Research about wild elephants tends to focus on topics such as maternal

investment, allomothering (caretaking of infant by animals other than the mother), communication, reintroduction and conservation (5,6,7,8,9).

Captive Elephant Research Controversy

Conservation groups argue that keeping elephants in captivity should not be allowed due to the small exhibits and the separation of the elephants from their families (13). Elephant conservation groups, such as Species Survival Commission African Elephant Specialist Group, state that much of what can be learned from these animals has already been learned in detail and that the focus of research in zoos is only on solving captive animal management and breeding problems (2). Captive populations may not be helpful in deducing wild elephant behavior because they perform atypical behaviors, such as swaying or head bobbing, from being in an exhibit that is too small to allow for natural behaviors (2). According to the Association of Zoos and Aquariums (AZA) standards, indoor exhibits must have a stall for each adult elephant and must be larger than 600 ft² with ceilings taller than 24 ft (21). Outdoor areas are not specified by AZA standards except that the elephants must have enough space to be able to conduct natural behaviors (21).

Animal activist groups such as In Defense of Animals, do not recognize the contributions that accredited zoos are making toward elephant conservation and research (3, 14). The benefit of keeping and breeding animals in captivity is not limited to reintroduction, public education, research about elephant communication, and research about reproductive biology that can promote the long-term survival of this species in the wild (3). For example, Freeman et al. conducted research in 2004 about hormonal cycles and dominance status of zoo elephants, which is now being applied in field research of wild elephants (15). Also, techniques for satellite tracking of elephants have also been tested with zoo elephants

before being used in the field (3). Zoos, sanctuaries, and other areas with captive animals provide scientists with easier access to observe the animal when conducting research.

Being able to constantly view elephants and to easily keep track of specific animals is a unique opportunity when researching animals in the field. There are 284 elephants living in American zoos and the related current research focuses on elephant health, behavior, and evolutionary history (16).

Research of Wild Elephants

Observing the habits of wild elephants is extremely difficult because of the non-invasive field research required, such as tracking individual elephants in Africa. In the summer of 2012, a team of researchers from Stanford University tried to overcome this problem by using solar panels to power their entire campsite and create an environment where they could quietly observe, videotape and photograph wild elephants at the Mushara waterhole in Etosha National Park, Namibia (4). They had success by taking hundreds of solar powered photos to identify and track behaviors of individual elephants that they had already tagged (4). By using the solar powered camp they were able to be a fully functioning lab that did not need to bring loud, polluting equipment that would interrupt the animals.

Another study conducted by P.C. Lee in 1987, used photographs and drove cars as close as 2 meters to the elephants in order to track them (5). They were able to get relatively good observations, but they still had issues with elephants being influenced by close human proximity and in some areas (such as swamps) where detailed observations on submerged elephants were difficult (5). Part of their research examined elephant calves distances to others (5). They found that immature elephants, birth to eight years, were found within 5

meters of their mother in 80.5% of the scans (5). They observed that as the calves, especially male calves, aged they tended to be found at increasing distances to the mother but the distance to non-mother neighbors did not change greatly (5). When in a group, calves had at least one other animal as a close by neighbor (5). Neighbors of the immature elephants all seemed to not be randomly drawn from those in their group (5). Females were found as a neighbor to the calves 69% of the time while males were only neighbors to the calves 31% of the time (5). When a calf also had another calf as a neighbor who was around the same age, they tended to be within 1 meter of each other (5)

Captive Population Research

There has also been research of captive populations that examined spatial variation among animals. A study conducted by Cassinello and Calabuig on ungulates, specifically a captive population of aoudad (*Ammotragus lervia*), showed evidence of kin recognition (23). The spatial associations between herd mates of the captive population were measured in order to determine what factors influences the individuals' association choices (23). They found that mother to calf interactions are characterized by higher proximity than others, especially during the suckling period of younger ages (23). Additionally, they found that female social rank did not influence the spatial associations between the different herd members (23). The results were compared to species in the wild, which was also characterized by a strong mother to calf bond (23).

Another study by Garaï, looked at captive female elephant interactions and spatial distances (24). He concluded that the calves played a very important part in elephant society (24). One of the calves of the group had no direct kin in the captive herd (24). He found that this calf was involved in more friendly interactions with adult elephants in the

herd compared to the other calves of the group that were related to the adults (24). Garaï believes that because elephant calves in the wild have more than one female to look after them, this calf may have been trying to find an allomother to take care of her (24).

Research Elephant Population

Reid Park Zoo located in Tucson Arizona, United States, has been maintaining a herd of six elephants in a 4.5-acre exhibit since 2012. There are three adult elephants: a 23 year-old male and two 23-year old females who are from Swaziland, South Africa. They came to the U.S. in 2003, along with eight others, and were introduced to either the Lowry Zoo in Tampa, Florida or San Diego Safari Park California. They were relocated to the U.S. because of a large killing that was scheduled in Swaziland in 2003 by management authorities due to overpopulation of elephants in the area (1, 17). Farmers in the area were angry with the elephant herds for stampeding their fields and destroying their crops (1).

One of the females and the male had two male calves while living at San Diego Safari Park. The oldest calf was born in 2007 and is seven years old while the youngest calf was born in 2010 and is four-years old. Elephants are considered immature until they are completely weaned off their mother's milk, normally between five to ten years (19). In 2012, the family, including the other female, who acts as an aunt figure in the herd, was moved to Reid Park Zoo where they still reside in 2015. The other female was brought with the family because of Association of Zoos and Aquariums standards that require at least three elephants or larger groups are needed in an exhibit because elephants are social animals (20). In August of 2014, the parents of the two male adolescent elephants gave birth to a female.

Specific question/objectives

My research examines the spatial changes of the herd with the growth of the newborn elephant. Specifically, how does the female calf's distance to different members in her herd change over time? By measuring her distance to all nearby members of her herd, spatial variations will be able to be analyzed. The research by P.C. Lee that is discussed earlier, found that a calf is dependent on its mother for nutrition and protection, especially within the first 24 months of a calf's life (5). Calf proximity is important in order to provide a safe environment for the newborn to grow in (5). This research on wild elephants will also be used to see if there are any comparisons that can be made between the wild elephant calves and the newborn calf at the zoo (5). However, it will be important to distinguish the many differences between these two studies, such as sample size, area size, and other parameters.

METHODS**Site Location**

I collected data at the Reid Park Zoo in Tucson Arizona, United States, at the Expedition Tanzania Elephant Exhibit. The 4.5-acre elephant exhibit consists of 2 large areas. The first area, about 1.75 acres, is a small yard containing a pool, river, mud wallow, and sand. The public can see this first area at all times. The second area is 2.75 acres and located 1.5 acres away from public viewing. It consists of a very large grass yard, sand yard and some mud wallows. I took all measurements when elephants were in the first area due to the limited visibility of the second area.

Data Collection

I measured the female calf's location with relative distances to members of her family who were within 45 meters of her at each measurement interval. For one day each week, 5 measurements were recorded for an hour, 12 total measurements, for a total of 14 weeks (November 23, 2015 – March 9, 2015). I used a Nikon Coolpix S70 camera, with 5-25mm 1:3.9-5.8 zoom with the lens completely zoomed out, a magnification of 0.13. Measurements were recorded on the weekend (Saturday-Monday) between the hours of 1030- 1230. Week 5, 8, 10, 12 and 13, I was able to get all my measurements in 1 day. All of the other weeks I had to visit the elephant exhibit 2 different days in order to get 12 total measurements of elephants in the first area of the exhibit.

Each image taken was put into the program Paint 2 to determine the pixel count for the image. All pictures were 640 x 480 pixels. The program allowed me to count the number of pixels of the mother elephant (who was present in every picture) and the pixels in between each elephant and the female calf. The 3-meter height of the mother elephant was used as a constant to convert the distance in pixels to a distance in meters. Once this information was obtained the following equation was used:

$$\text{Distance (m)} = 3\text{m} \times ((\text{pixel distance} \times 9 \mu\text{m}) / (\text{pixel height mother elephant} \times 8.94 \mu\text{m}))$$

RESULTS**TABLE 1: Average Weekly Distances of Each Member of Herd to Female Calf**

Week	23-year old Mother	4-year old Calf	7-year old Calf	23-year old Father	23-year old Aunt
1	2.05	4.34	11.58	9.89	N/A
2	1.70	10.17	11.19	22.23	17.93
3	0.73	10.21	5.74	6.16	14.25
4	2.39	5.17	7.88	13.03	11.48
5	3.41	14.03	7.66	12.02	8.79
6	2.37	11.13	18.41	11.02	28.80
7	3.70	10.35	13.49	13.57	0
8	3.66	9.94	8.67	13.57	24.16
9	4.78	7.29	11.95	7.69	N/A
10	2.52	9.89	14.49	12.98	6.40
11	4.73	5.53	10.25	10.07	17.75
12	4.92	12.01	12.02	5.67	N/A
13	1.56	9.94	19.92	20.64	N/A
14	3.71	7.19	16.39	11.63	15.69
Total Average	3.02	9.09	12.12	12.16	14.53
% Change	1.66	2.86	4.81	1.74	15.69

Table 1 shows the average weekly distances, in meters, of each member of the herd compared to the newborn female calf. The range of distances from female calf to mother was 0- 4.92 m, for the 4-year old brother was 4.34- 14.03 m, for the 7-year old brother 5.74-19.92 m, for the 23-year old father was 5.67-22.23 m, and for the 23-year old Aunt was 0-28.0 m. The percent change in distance was calculated for each elephant compared to the female calf to see the degree of changes.

FIGURE 1

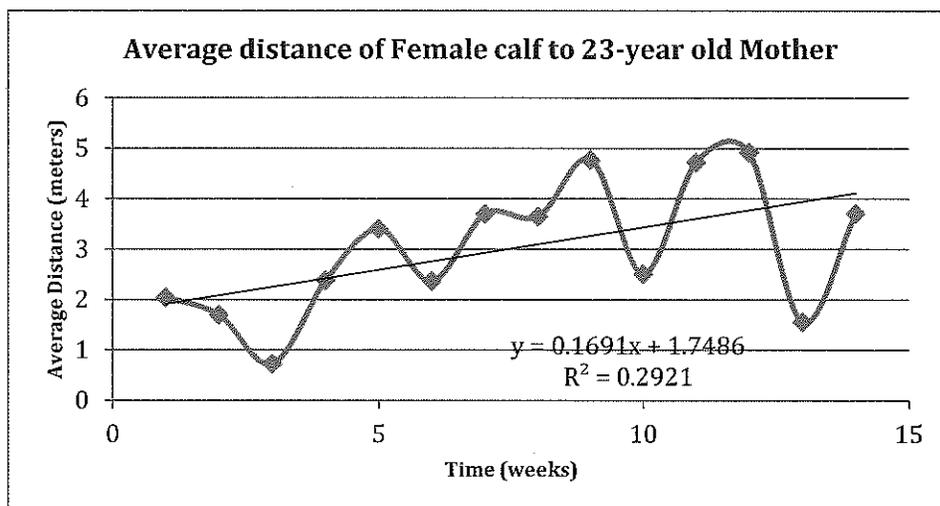


FIGURE 2

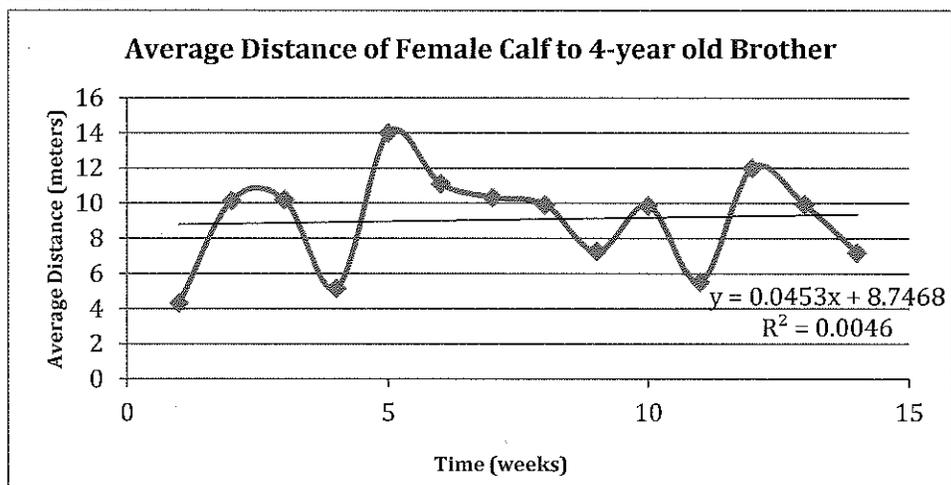


FIGURE 3

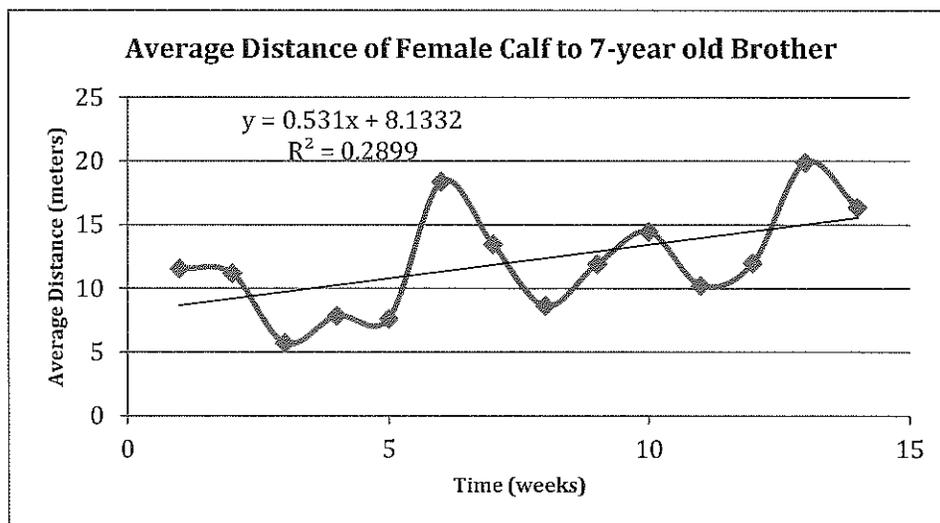


FIGURE 4

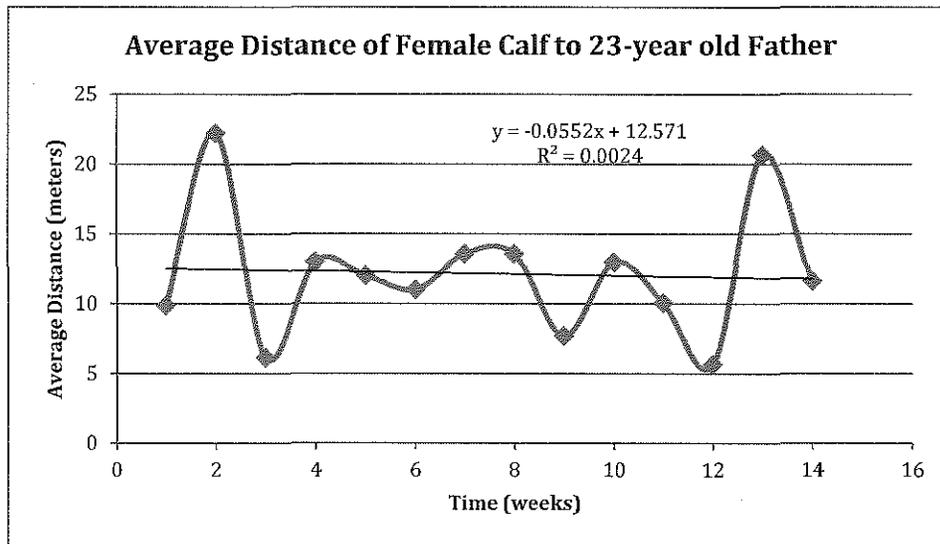
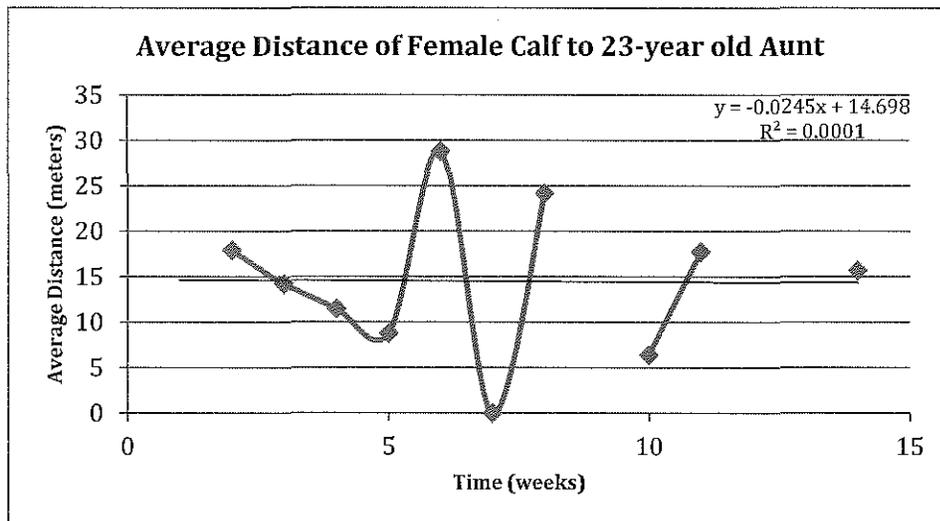


FIGURE 5



Figures 1-5 illustrate the average distances and the linear regressions of the changes in distance. The 23-year old mother had a slope change of 0.17, the 4-year old brother had a change of 0.045, the 7-year old brother had a change of 0.53, the 23-year old father had a change of -0.055, and the 23-year old aunt had a change of -0.025 (Figures 1-5).

TABLE 2: Pearson Linear Correlation between Female Calf and Herd Members

	23-year old mother	4-year old brother	7-year old brother	23-year old father	23-year old aunt
R-value	0.54	0.068	0.54	-0.049	N/A
P-value	0.045	0.82	0.047	0.87	N/A

Table 2 shows the results of the Pearson linear correlation performed on the average distances.

The R-value or correlation coefficient is always a number between -1 and 1, which expresses the degree that two variables change correspondingly. If one variable increases while the other one increases, then there is a positive correlation with a number closer to 1. If one variable decreases while the other one increases then there would be a negative correlation with an R-value closer to -1. The mother had an R-value of 0.54, the 4-year old brother had a value of 0.068, the 7-year old brother had a value of 0.54, and the father had a value of -0.049 (Table 2). The P-value is the probability that the results would have been found if the R-value were in fact zero or the null hypothesis. If the probability is lower than 5% ($P < 0.05$) then the correlation coefficient is statistically significant. The mother had a P-value of 0.045, the 4-year old brother had a value of 0.82, the 7-year old brother had a value of 0.047, and the father had a value of 0.87 (Table 2). The aunt does not have R or P values because she was missing measurements for multiple weeks, making a linear correlation impossible to conduct.

DISCUSSION

The female calf's distance did increase away from her mother, 3.02 m with a percent change of 1.66% from the first week to the last week (Table 1). The maximum distance that the newborn moved away from her mother was 4.92 m (Table 1). In P.C. Lee's study, he

found that calves were within 5 meters of their mother in 80.5% of the scans (5). My study supports this evidence of strong mother and calf bonds, even though the sample population and area of the study were both significantly smaller. The mother had an R-value that is close to 1, indicating that there was a positive correlation between the female calf's distance to her mother over time (Table 2). The P-value was found to be 0.045, concluding that the correlation coefficient was statistically significant between the mother and the calf (Table 2).

The female calf's distance to her 4-year old brother increased, 9.09 m with a percent change from the first week to the last week of 2.86% (Table 1). Using the linear regression, there was slight positive slope indicating again that the female calf's distance did increase away from her brother over time, but not as drastically as her distance increased from her mother (Figure 2). The 4-year old brother is the youngest elephant in the herd, besides the newborn, and according to P.C. Lee's study it would be likely that she would spend a large portion of her time with him (5). Looking at the results, it can be seen that there is no clear trend for the change in the 4-year old brother's distance relating to the newborn. He slightly increases his distance away from the newborn over time, which according to past studies this should be reversed. One reason that the 4-year old brother did not increase his distance toward the female calf could be because of not being close enough in age to the female calf to follow P.C. Lee's conclusion. The 4-year old brother had an R-value close to 0, indicating support for the null hypothesis (Table 2). The P-value was found to be 0.82 for the 4-year old brother, allowing the conclusion to be made that the correlation coefficient was not statistically significant (Table 2).

The female calf's distance to her 7-year old brother did increase, 12.12 m with a percent change of 4.81% from the first week to the last week (Table 1). Using the linear regression, there was positive slope indicating again that the female calf's distance did increase away from her brother over time (Figure 3). The 7-year old brother had an R-value close to 1, indicating that there was a positive correlation between the female calf's distance to her brother over time (Table 2). The P-value was found to be 0.047 for the brother, allowing the conclusion that the correlation coefficient was statistically significant (Table 2). P.C. Lee concluded that calves from birth to eight years of age were found within 5 m of their mother and from there continue to increase their distance away. The 7-year old brother has increased his distance from the female calf, and therefore the mother as well, since he is near the edge of this juvenile age range.

The female calf's distance to her father increased, 12.16 m with a percent change from the first week to the last week of 1.74% (Table 1). Even though the father had a large average increase in distance away from the female calf, it can be seen from the percent change that over the entire time period, he did not steadily increase his distance. Using the linear regression, there was slight negative slope indicating that the female calf's distance became slightly closer to her father over time (Figure 4). In the wild, males do not stay with the herd but only socialize with a family unit in order to reproduce. There is only one male elephant in a captive elephant herd per location due to aggressive behaviors that they have toward each other during the mating season (12). During this study, I found that the father tends to spend a large portion of his time with the mother, since they are mates, which therefore causes him to spend a lot of time with the female calf since the calf was never farther than 4.92 m away from her mother. I noticed that the calf measurements that were

close to the father were also measurements that were close to the mother, providing evidence that the mother's distance may have played a factor in the variability of the father's measurements. This explains why the father had large oscillations in his data with the calf, since his distance seemed to depend on if he was interacting with the mother during the time of measurement. The father had an R-value that is slightly negative and close to 0, indicating that there is more support for slight negative correlation and null hypothesis (Table 2). The P-value was found to be 0.87 for the father, allowing the conclusion to be made that the correlation coefficient was not statistically significant and there were no clear trends between the father and female calf (Table 2).

The female calf's distance to her aunt increased, 14.53 m with a percent change from the first week to the last week of 15.69% (Table 1). Using the linear regression, there was slight negative slope, but very close to 1, indicating that the female calf's distance did not change very much over time (Figure 5). The aunt was not within the 45 m to the female calf during the time of measurement for 4 different weeks of measurements. This led to holes in the data and therefore no precise trends can be accurately concluded. From the results collected, it can be seen that her distances appear random and variable. When observing the elephants, it was noted that the aunt seemed to be afraid of the mother. The mother is the female matriarch in the herd, giving her the power over all of the other herd members besides the father (25). This could be the reason for the lack of trend between the female calf and aunt, since the newborn was always with her mother and aunt would not want to be in the same area. The captive elephant study by Garai, found that the calves did spend time significant time with allomothers, which may not have been the case in my study due

to the smaller herd size. The aunt had the largest maximum distance from the female calf, 28.0 meters, most likely due to these same reasons (Table 1).

There was an overall trend in the average distances with relation to the female calf; mother had a distance of 3.02 m, 4-year old brother had a distance of 9.09 m, 7-year old brother had a distance of 12.12 m, father had a distance of 12.16 m, and the aunt had a distance of 14.53 m (Table 1). From this correlation, it can be concluded that the female calf spent more time with her mother and younger siblings, and spent less time with the older herd members. P.C. Lee's study concluded that young calves always have at least one neighbor close by, which was indicated by my study as well. Looking at the average distances (Table 1) it can be seen that the mother tends to fill this role, but looking at the raw data of 12 measurements from each hour each week, it can be seen that other family members filled this role frequently as well.

I also found trends among the elephant's distances when comparing the mother's distance to each of the herd members. All of the father's distances that were close to the calf also had close distances to the mother, showing that the father may have been spending time with the mother and not the calf for all of these measurements, helping to explain why there was not a clear pattern between the father and the calf. Also, when the aunt had close distances to calf, she had far distances from the mother. It can be concluded that the aunt was trying to avoid being near the mother because of the hierarchy of the elephants in the herd. This also explains why there were very few measurements between the calf and the aunt, since she was greater than 45 m away from the calf when trying to keep her distance from the mother. The distance between the mother and her 4 and 7-year old son did not have any clear trends.

The study by P.C. Lee stated that neighbors that were near the calf would be female 61% of the time and male 31% of the time. I was unable to verify this due to the small number of elephants in the herd, uneven distribution of genders in the population, and smaller active area. I have lower confidence using the slopes calculated with the linear regressions, because of the R^2 values for each figure being so close to 1 and not close to 100.

Additionally, conducting the experiment for a longer time period would have allowed for much more precise and clear trends since there would be more time to continue measuring the growth and changes in the female calf.

Overall, the female calf had a statistically significant correlation of increased distance with her mother and 7-year old brother. Looking at the average distances, maximum distances, and percent change increases, it can be seen that the mother was the closest to the calf, then the 4-year old brother, 7-year old brother, father, and aunt over 14 weeks.

Comparisons can be made between my study and P.C. Lee's study of wild elephants.

However, differences in our sample sizes (my study had only 6 elephants and he had 600-650 elephants) and living space areas (my study only used 1.75 acres and he used an area larger than 3000 km²) are different enough to have discrepancies in accurate comparisons

(5). Comparing my study to research conducted by Cassinello and Calabuig of captive ungulates, allows for more controlled comparisons to be made (23). They found that mother to calf interactions are characterized by higher proximity than others, especially during the suckling period of younger ages (23). My study found that the mother had the closest distances to the calf, and had the smallest maximum distance, which supports their conclusion. Additionally, they found that female social rank did not influence the spatial associations between the different herd members (23). My study found the opposite of this,

since the aunt of the herd had some of the farthest distances away from the calf during my study.

Being able to conduct a longer study would allow for variability in environmental conditions, such as seasonality, to be taken into account. Tucson has similar conditions to Swaziland, South Africa where the elephants are originally from, but the winter weather is much colder than conditions found there. A study by Young and Van Aarde, found that the survival of an elephant is dependent on the dry season roaming activities, rainfall, and the distribution of food (22). They found that the survival of calves' ages 4-7 years decreased during dry seasons, but was not a factor in calves' ages 1-3 or older than 7 years (22).

Determining the effect that this more extreme temperature has on the behaviors would help in knowing the possible ranges of environment that elephants could be relocated to. Future experiments should look the calf's proximity to her herd members on days with different temperatures and weather, such as rainy or cold days.

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