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Utilizing First Occurrence, Nursing Behavior, and Growth Data to Enhance Animal Management: An Example with African Elephants (*Loxodonta africana*)

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One of the many goals of zoological institutions is to actively breed endangered species to enhance conservation efforts. Unfortunately, many of these species are not reproducing at high enough levels to sustain populations within zoos. Low reproductive success and high infant mortality are two areas of concern for some of these species. Collecting behavioral data on developmental milestones following successful births can create a database of information to aide animal management to help make more informed decisions during subsequent births. The current study provides valuable information for African elephant calf developmental norms and demonstrates how data on first occurrences, nursing behavior and growth patterns can aide animal management. Data were collected on eleven African elephants (*Loxodonta africana*) at the San Diego Zoo Safari Park in Escondido, CA of which ten have survived. Results show that on average African elephant calves were standing within 40 minutes, attempted to nurse within an hour and a half, and successfully nursed within six hrs. There were no significant differences in nursing rates, growth patterns, or first occurrence behaviors between males and females during the first 75 days of life and elephants gained on average 0.59 kg/day over that same period of time. Results also show a significant change in nursing behavior on day 22 for the elephant calf that died. This information is intended to serve as a resource for elephant managers with newborn African elephants and to serve as a model to develop similar type databases for other species in need within zoological institutions.

Many of the animal populations within zoological institutions are currently not self-sustaining (Lees & Wilcken, 2009). African elephants are one of these species and without increased reproductive success and decreased levels of infant mortality the population will not sustain (Wiese & Willis, 2006). Currently efforts are underway to examine acyclicity in elephants (Dow, Holaskova, & Brown, 2011; Freeman, Guagnano, Olson, Keele, & Brown, 2009) and zoos have been using artificial insemination to increase reproductive success (Hildebrandt et al., 2006). However, there is little research to determine developmental norms of elephant calves which would allow elephant managers to know normal development patterns for elephants. Having this type of information would allow managers to know when it is critical to intervene if an elephant is not developing normally.

In the wild, there has been a good amount of research on elephant births and calf development. African elephants are born after a gestation period of about 21.5 months with males weighing approximately 120 kg and females weighing approximately 95 kg (Poole, 1996). On average, calves that are born to older and larger females give birth to larger calves (Lee, 1986). Nutrient content is acquired by calves exclusively through nursing over the first three months of

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life (Lee & Moss, 1986). The average duration of a nursing bout for an African elephant calf is about 86 s (Lee & Moss, 1986). It is estimated that elephant calves in the wild nurse at a rate of 170 s/hr for males and 130 s/hr for females. Based on the size of the hind footprint it is estimated that males grow more quickly than females following birth likely due to greater time spent nursing (Lee & Moss, 1986). However, in the wild it is difficult to acquire data on first occurrences as one must be present at the time of birth and continuously follow those individuals over weeks and months. In addition, it is important to ensure behavioral observations are not impacting the behavior of wild animals. Even with this difficulty, some data are available and it has been reported that first successful nursing ranges between one and a half and four hours on average (Moss, 1988).

Within zoological institutions the amount of data on African elephant development is more limited. However, the smaller environment allows for detailed observations in a semi-controlled setting. Andrews, Mecklenborg, and Bercovitch (2005) found that on average the duration of nursing for one male African elephant calf was 76 s. This individual weighed 104 kg at birth and gained approximately 0.385 kg/day throughout the first three months of life. This weight at birth and average weight gain is slightly lower than that reported as the average weight at birth for males (125 kg) or growth (0.90 kg/day) in zoos (Kowalski, Dale, & Mazur, 2010). Bercovitch and Andrews (2010) found when combining data on elephants from both wild and zoological studies that on average they were standing at 35 min, attempting to nurse at 10.5 hrs and successfully nursing on average after just under 11 hrs. The time until nursing reported was quite a bit longer than that reported by Kowalski et al. (2010) which was just over three and a half hrs. The time until standing was also slightly longer than the 11 min reported by Kowalski et al. (2010).

While some data exists on developmental milestones and behavioral norms for elephant calves, there is a wide range in values. The goal of the current study is to report on average times for the ten successful births of African elephant calves at the San Diego Zoo Safari Park and also provide expected maximum values of when to intervene if important milestones have not been reached by an elephant calf. In addition, changes in nursing behavior for one elephant that didn't survive are presented as a potential tool for elephant managers overseeing future births of African elephants. This type of information can help guide elephant management for any future births to hopefully reduce infant mortality which is one of the goals of creating a sustainable elephant population in zoological institutions.

Method

Subjects and Exhibits

The herd of African elephants (*Loxodonta africana*) at the San Diego Zoo Safari Park (Escondido, CA) was initially comprised of one adult male and six adult females imported from Swaziland back in 2003 saving them from a scheduled culling event. Between 2004 and 2011 there have been 11 elephant calves born into the herd (Table 1). In 2009 the Safari Park also added another mature bull; however he was housed separately until his habitat was linked to that of the rest of the herd in late 2010. All calves included in the current study were sired by the original adult male with the exception of the first calf born in 2004 who was sired by a wild bull.

Initially the elephants were exhibited in an approximately 13,000 m² main exhibit with two additional indoor barn facilities. In December of 2010 the elephant's exhibit space was expanded to approximately 22,100 m² by connecting the two habitats. The additional space added another large exhibit area, two more holding yards and two additional indoor barn facilities. During the course of the study animals were exhibited in the two main yards except during husbandry training or cleaning of the main exhibit. The elephants were given access to both the main exhibits

and indoor holding areas at night during the winter months. For a complete description of husbandry procedures and elephant management methods please refer to Andrews et al. (2005).

Table 1
African elephant calves born at the San Diego Zoo Safari Park between February 2004 and September 2011

Elephant	DOB	SEX
E1	02/23/2004	M
E2	09/11/2006	F
E3	03/11/2007	M
E4	09/19/2007	F
E5	11/28/2007	F
E6	03/13/2009	M
E7	02/14/2010	M
E8	04/12/2010	M
E9	05/12/2010	M
E10	12/27/2010	M
E11	09/26/2011	M

Design and Procedure

Observations were conducted on elephant calves 24 hrs per day for the first five weeks after birth. This included recording the exact duration of all nursing bouts with a stopwatch, recording the exact date and time of birth and specific first occurrence behaviors, and collecting daily weights for elephant calves. After the first five weeks, daily weights were still continued as well as documenting specific first occurrence behaviors if the behaviors occurred while animal care staff was present. Weights and first occurrences of specific behaviors are presented for the first 75 days of life for surviving calves. Maximum expected first occurrences were calculated by adding two standard deviations to the average time elapsed since birth. This gives the upper end of a 95% percent confidence interval for all first occurrence behaviors. Mann-Whitney U tests of significance were utilized for all comparisons between male and female calves due to a small sample size. A Pearson product moment correlation was utilized to examine the relationship between male and female growth patterns. The Wilcoxon signed rank test was utilized to examine nipple preference and the change point test of significance was used to look for changes in nursing rates for the calf that died. For all statistical tests the alpha level was set at $p < 0.05$.

Results

Ten of the eleven African elephants born at the San Diego Zoo Safari Park since 2004 have survived past 75 days of life. Table 2 is a summary of the average and expected maximum times for first occurrence behaviors of African elephant calves that survived. On average, elephants were standing within 40 min, attempting to nurse within an hour and a half, and successfully nursing within six hrs. There were no significant differences between males and females for the timing of any first occurrence behavior (Right Itself: $U(5) = 0.00$, $Z = -1.954$; Assisted Stand: $U(7) = 2.00$, $Z = -1.414$; Successful Stand: $U(8) = 4.00$, $Z = -1.043$; Attempted Nurse: $U(8) = 6.00$, $Z = -0.447$; Successful Nurse: $U(8) = 4.00$, $Z = -1.043$; Defecation: $U(8) = 7.00$, $Z = -0.149$; Urination: $U(8) = 2.00$, $Z = -1.640$; Eat Feces: $U(7) = 2.00$, $Z = -1.414$).

Table 2

Average duration after birth and maximum expected time for first occurrence behaviors

Behavior	Average Time	Expected Maximum Time	N
Right Itself	10 Minutes	30 Minutes	5
Assisted Stand	30 Minutes	80 Minutes	7
Successful Stand	40 Minutes	90 Minutes	8
Attempted Nurse	1.5 Hours	4.5 Hours	8
Successful Nurse	6 Hours	15 Hours	8
Defecation	7 Hours	24 Hours	8
Urination	7 Hours	24 Hours	8
Eat Feces	3.5 Days	1 Week	7

Note: Only certain first occurrences were included which explains the deviation in sample size (N).

Average weight for survived males and females is displayed in Figure 1. Average weight at birth was 106 kg (Range 98 - 122 kg) for males and 97 kg (Range 87 - 108 kg) for females. On average, elephant calf weights were similar for survived males and females over the first 75 days of life ($r = 0.918, p < 0.01$). During this time, elephants gained on average 0.59 kg /day regardless of sex. Average duration of nursing bouts for survived elephant calves during the first thirty days was 42.87 s (Range 25.52 - 70.09 s) and daily time spent nursing was 92.51 min (Range 65.89 - 132.04 min). This would equate to approximately 231.3 s/hr over an entire 24-hr period. Males and females did not differ significantly in average duration of bouts ($U(10) = 5.00, Z = -0.783$) or total daily time spent nursing ($U(10) = 8.00, Z = 0.000$). Elephant calves also did not show a preference for nipple selection (L: 49.59%, R: 50.41%; $Z = -0.857, p = \text{n.s.}$) or average bout duration for each nipple (L: 42.20 s, R: 43.28 s; $Z = -1.423, p = \text{n.s.}$).

Elephant 5 passed away on February 4, 2008 which was 68 days after birth. Average duration of nursing bouts over the first 30 days of life compared to the two surviving females is displayed in Figure 2. At day 22 there is a significant change in nursing behavior ($Z = 3.67, p < 0.01$) with a decrease occurring after this time.

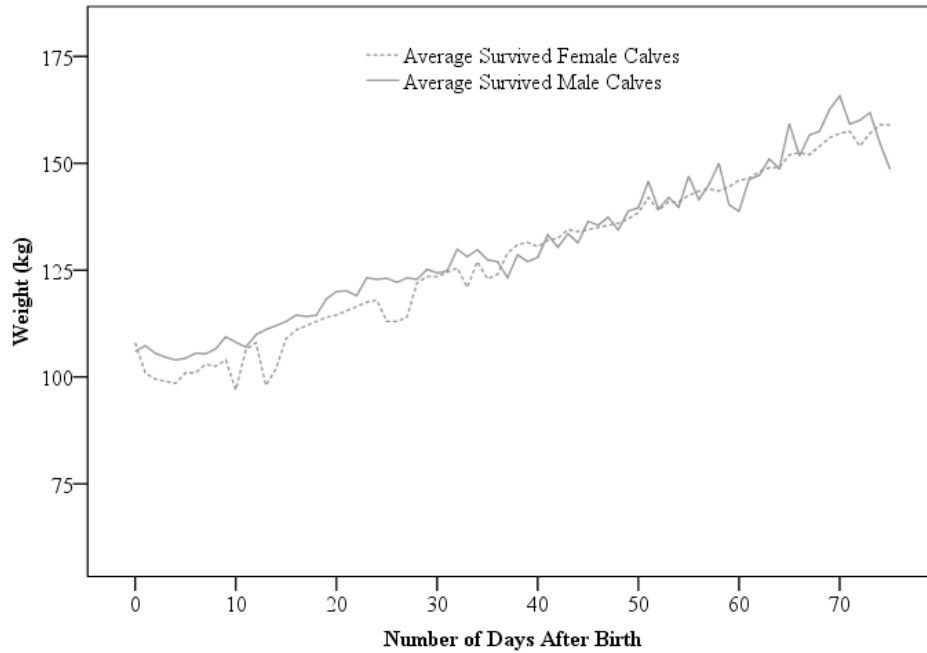


Figure 1. Average weight of survived male and female elephant calves over the first seventy-five days of life.

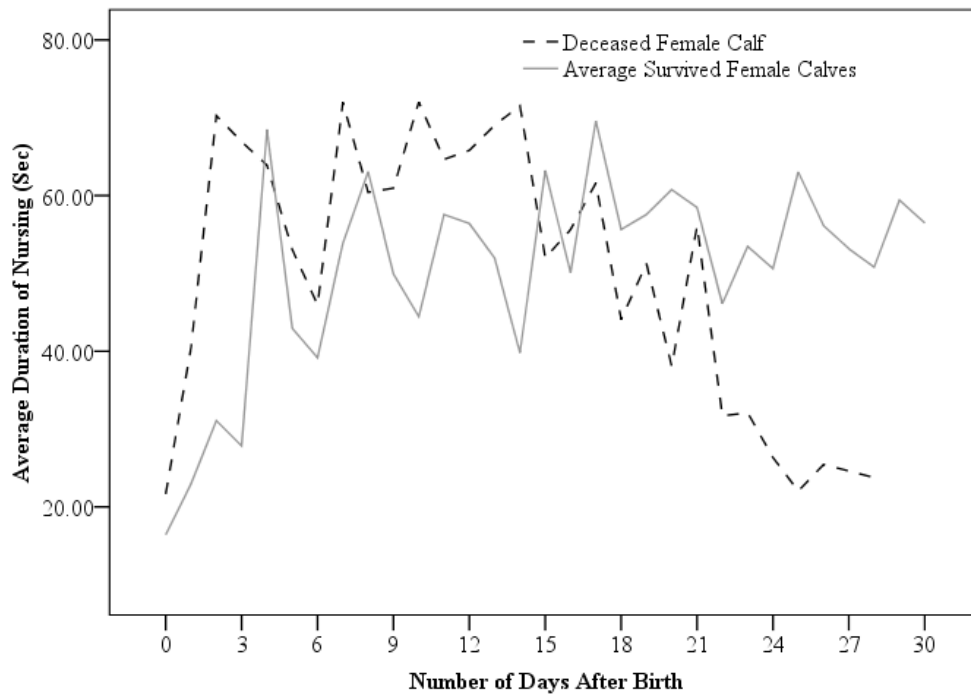


Figure 2. Average duration of nursing bouts for deceased compared to survived female elephant calves over first thirty days of life.

Discussion

The information contained in this manuscript is meant to serve as a guide for animal care managers with newborn African elephants and highlights the importance of collecting behavioral data to determine if a calf is developing normally. This information presented can also be used as a model to develop similar databases for other species in need. If enough institutions utilize data on first occurrences, nursing behavior and growth patterns this could help decrease infant mortality rates for elephants and many other species through more informed animal management.

The success of the breeding program at the San Diego Zoo Safari Park has allowed for the creation of norms for critical first occurrence behaviors. Using confidence intervals the upper end (expected maximum time) is also provided as a worst case indicator meaning that if this time is reached elephant care staff should consider intervening as development is likely outside of normal development. On average, elephants are standing within 40 min, attempting to nurse within an hour and a half and successfully nursing within six hrs. This is similar to the values reported on wild elephants (Moss, 1988) and those of Kowalski et al. (2010) based on a survey of elephants in zoos. The value reported by Bercovitch and Andrews (2010) was considerably longer on average at 11 hrs for time until successful nursing and is likely due to an outlier as the maximum value reported was quite large. However, the average value of 11 hrs is still within the maximum expected time reported during the current study. Utilizing the expected maximum time information, elephant managers can make more informed decisions on whether it is critical to intervene.

Collection of nursing and growth data can provide an additional metric to ensure a calf is developing normally. Nursing bout duration for the current study was on average 42.87 s with animals spending 231.3 s/hr nursing over a 24-hr period. This average bout duration is about half that reported on wild elephants but the total time spent nursing is almost double (Lee & Moss, 1986). The differences between these studies could be due to methodological differences or might relate to differences in nutritional content of the diets and should be a topic of future research.

The fifth elephant calf that was born on November 28th, 2007 passed away on February 4th, 2008. Before she died, this calf was able to be pulled from its mother to supplement feeding due to using behavior as an early indicator. If animal care staff had been relying on weight loss, this situation would not have been detected until approximately one to one and a half weeks later. In this situation, the birth and initial subsequent rearing was no different than any other births at the San Diego Zoo Safari Park. However, the dam did not deliver the placenta even with clinical assistance. Approximately 21 days post-parturition, staff became more concerned that retention of the placenta had affected her ability to lactate. Shortly after this time, a significant change in nursing bout duration was detected. The calf was pulled in an attempt to supplement intake by bottle feeding while returning the calf to the dam after each feeding. This practice carried on from day of life 26 through 28 at which point the calf was permanently removed from the dam to reduce stress as separations were becoming increasingly traumatic. Despite intensive efforts, the calf died on day of life 68 partially due to other confounding clinical issues. Although ultimately un-successful in this case, utilizing nursing bout duration as a metric may, in the future, alert animal care staff to a situation that needs attention. Although weight and growth data could also be utilized, relying solely on these could delay early identification of a problem.

Overall, the information presented within this manuscript can serve as a useful guide and metrics for elephant care managers and staff. We hope that by utilizing such information infant mortality for this species will decrease as animal care staff will know time frames for typical development for African elephant calves. This information and the methods used can also serve

as a model for other species where infant mortality rates are high and highlights the importance of collecting behavioral data within zoological institutions.

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