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Nicole L. Kowalski
Indianapolis Zoological Society

Robert H.I. Dale
Butler University, rdale@butler.edu

Christa L. H. Mazur
Indianapolis Zoological Society

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A survey of the management and development of captive African elephant (*Loxodonta africana*) calves: birth to three months of age

Nicole L. Kowalski, Robert H. I. Dale, Christa L. H. Mazur

Indianapolis Zoological Society, Indianapolis, Indiana
Department of Psychology, Butler University, Indianapolis, Indiana

Abstract

We used four surveys to collect information about the birth, physical growth, and behavioral development of 12 African elephant calves born in captivity. The management of the birth process and neonatal care involved a variety of standard procedures. All of the calves were born at night, between 7PM and 7AM. The calves showed a systematic progression in behavioral and physical development, attaining developmental milestones at least a quickly as calves in situ. This study emphasized birth-related events, changes in the ways that calves used their trunks, first instances of behaviors, and interactions of the calves with other, usually adult, elephants. Several behaviors, such as the dam covering her calf with hay and the calf sucking its own trunk, were common in the captive situation and have been observed in situ. Overall, the behaviors of the calves resembled those observed for African elephant calves in situ. These data should help in the management of African elephants under human care by providing systematic reference values for the birth and development of elephant calves.

Introduction

Relatively few captive-bred African elephants (*Loxodonta africana*) have given birth to calves in North America and Europe. For example, there have been approximately 55 African elephant calves born in North America during the 30 years between 1978 and 2007 [Olson, 2007]. Until recently, the situation was severe enough that some doubted the captive African elephant population in North America would survive [for example, Olson and Wiese, 2000]. Over the past 3 years, however, 16 African elephant calves have been born in North America [Deborah Olson, personal communication, 12/21/07]. In other words, about a third of the calves born during the last 30 years have been born in just the last 3 years. Survival of the captive African elephant population will require that the recent fecundity be maintained.

In this context, professional elephant handlers, veterinary staff, and researchers will benefit from more knowledge about the birth process and calf development and care in captivity. There are some recent surveys of the birth and development of Asian elephant (*Elephas maximus*) calves in captivity [Dastig, 2002; Doyle et al., 1999], but there are almost no corresponding data for captive African elephant calves [although see Andrews et al., 2005; Bercovitch and Andrews, 2008; Berg, 1987; Oerke et al., 2006; Reuther, 1969]. Recently, Lee [1986], Lee and Moss [1986,

1999], Moss [1988, 2000], and Poole [1994, 1996] have examined the behavioral development of African elephant calves in situ and have noted some sex differences in the pattern of development.

Other researchers have described the behaviors of adult African elephants in captivity [Berg, 1983; Partan et al., 2000a, b], in situ [Kahl and Armstrong, 2000a, b, 2002; Shoshani and Knight, 2000; Sukumar, 2003], and in both contexts [Dale et al., 2004; Kuhme, 1963]. This report emphasizes the behavior of African elephant calves over the first 3 months of life. Its main purposes are to provide a more detailed description of the management of the birth process in captivity and to establish the timing of physical and behavioral developmental ''milestones'' for captive African elephant calves. The information should be useful both for the management of captive animals and for the investigation of wild populations.

Materials and Methods

We constructed four surveys to assess 12 African elephant calves' behavior and physical development from birth to 3 months of age. The four surveys also assessed various aspects of the birth process, for both calf and dam. The surveys covered the following periods: Prebirth–48 hr, 48 hr–2 weeks, 2 weeks–1 month, and 1 month–3 months of age. Each of the four surveys consisted of about 50 questions. Some questions were repeated across multiple surveys resulting in the inclusion of 78 unique questions in the study (Appendix). To simplify data presentation, we combined the results of two questions (#56 and #57) about the calf placing inert matter (rocks, dirt, sand) in its mouth and two questions (#73 and #74) about finding inert matter (rocks, dirt, sand) in a calf's stool. Overall, we obtained survey data from four animals at the Indianapolis Zoo, Indianapolis, IN, USA (Ajani, Amali, Kedar, and Zahara), three animals at Disney's Animal Kingdom, Orlando, FL, USA (Kianga, Nadirah, and Tufani), two animals at Riddle's Elephant and Wildlife Sanctuary, Greenbrier, AK, USA (Batir, Maximus), and one animal from each of three zoos: Toledo Zoo, Toledo, OH, USA (Louie), Zoologischer Garten Wuppertal, Wuppertal, Germany (Mongu), and Tiergarten Scho¨nbrunn, Vienna, Austria (Bongi). Ajani, Kedar, Louie, Maximus, and Tufani were male calves. The other seven calves were female.

We obtained data for Ajani, Amali, Batir, and Maximus (see Table 1) retrospectively, relying on daily logs, journals, and veterinary records (N. Kowalski examined the records for these animals). We obtained data from the other eight calves proactively, sending each survey to an institution before each of its calves reached the age examined by that survey. A liaison at each zoo filled out the surveys (see Acknowledgments). In addition to the demographic information provided in the surveys, we obtained data on the mode of conception, the gestation period, and the age of the dam at parturition from published sources (press releases, articles and the AZA, and EAZA elephant studbooks).

Table 1. Demographic information regarding the calves

Name (sex)	Dam (age/ parity) (Years/calf #)	Birth-time (00:00)	Gestation (days)	Weight (kg)	Shoulder height (cm)	Foot circumference (cm) [Front/rear]
Ajani[a] (M)	Ivory (18/1)	07:00	642	114	—	—/—
Amali[a] (F)	Kubwa (24/1)	04:31	653	91	79	43/46
Batir[b] (F)	Tonga (24/1)	01:31	645	98	89	44/48
Bongi[b] (F)	Punda (12/1)	21:05	641	109	87	—/—
Kedar[a] (M)	Kubwa (29/2)	20:30	627	91	87	46/46
Kianga[b] (F)	Vasha (19/1)	19:15	641	104	84	—/—
Louie[a] (M)	Renee (24/1)	23:48	—	125	91	—/—
Maximus[b] (M)	Lil Felix (20/1)	03:02	—	128	89	47/43
Mongu[b] (F)	Tonga (17/1)	22:50	—	93	—	—/—
Nadirah[b] (F)	Donna (21/1)	00:24	642	106	86	—/—
Tufani[a] (M)	Moyo (22/1)	22:05	635	134	112	—/—
Zahara[a] (F)	Ivory (24/2)	21:05	638	118	90	—/—

[a]Conceived through artificial insemination.

[b]Conceived through natural breeding.

Data Analysis

The results of the surveys were stored in a Clarisworks® database, then summarized in an Excel® file. Where possible, data for the birth process and the first 2 days were recorded in hours and minutes (00:00–48:00 hr): from Day 3 on, only the day of an activity or behavior was recorded. The zoo liaisons were not able to answer every question on every survey: Some questions were not answered, and some were answered with ‘‘unsure,’’ ‘‘?,’’ or an equivalent response. Tables 1–5 summarize the answers given to each of the 78 questions in the surveys (see Appendix A) and specify, for each question, the number of observations contributing to the summary.

For assessing data on the time of birth, we used the Binomial test [Kirk, 2008]. We used the Kolmogorov-Smirnov two-sample test [Daniel, 1990; Lehner, 1996] to compare gestation periods, weights, and shoulder heights of the male and female calves, and the Kolmogorov-Smirnov one-sample test to compare the gestation periods for our calves with those observed in other studies [Daniel, 1990; Lehner, 1996]. To compare the calves' weights at different times and to compare the observed ages of primiparous dams with the median primiparous age found in another study, we used the Wilcoxon signed-ranks test [Daniel, 1990; Siegel, 1956]. For most observations of the times at which events occurred, we have reported the median score and the range of scores rather than the mean score and the standard error of the mean . There are three main reasons for this: Some behaviors were not observed for all calves within the first 3 months, so that there were no specific data-points for all 12 calves; the institutional liaisons responded to some questions with answers such as ‘‘occurred during this period’’ or ‘‘already observed,’’ so that the response to that question provided a time interval rather than a specific time, and the

distribution of scores was often asymmetrical (skewed), which would have rendered parametric statistical tests inappropriate [Kirk, 2008]. Unless otherwise noted, the criterion for any difference or effect to be statistically significant was $P < 0.05$, two- tailed test.

Results

Time of Birth, Length of Gestation, and the Age of the Dam

All 12 calves were born overnight between the hours of 19:01 and 07:00. This is a higher proportion than would be expected by chance (binomial test, $P = 0.0002$). Gestation lasted a mean of 640.4 ± 2.4 days (Table 1: median = 641 days; $N = 9$) and was not significantly different for the male (635 days; $N = 3$) and female calves (641.5 days; $N = 6$), Kolmogorov-Smirnov two-sample test, D (3, 6) = 0.67, $P > 0.10$.

We used the Kolmogorov-Smirnov one-sample statistic (D) to compare our sample with the gestation periods cited for African elephants in three other sources. In each case, we used the mean and standard deviation cited by the other source as the hypothetical population mean and standard deviation. Our sample was significantly different from the data obtained in situ by Moss [1983]: mean gestation period of 656 ± 4 days obtained for African elephants in situ, $D = 0.886$, $P < 0.01$, and from the mean gestation period of 657 ± 6 days found for African elephants ex situ by Meyer et al. [2004], $D = 0.866$, $P < 0.01$.

One calf, Bongi, was included both in our study and in a study of captive pregnant elephants by Oerke et al. [2006], who found the mean gestation period for African calves to be 642 ± 11 days. Therefore, we discarded Bongi's data and compared our estimate of the gestation period based on the remaining sample (640.4 ± 2.7 days, $N = 8$) with the data obtained by Oerke et al. [2006]: The difference was not statistically significant, $D = 0.267$, $P > 0.20$.

Moss [2001] has reported that African elephant dams in situ gave birth to their first calves at a median age of 14.1 years (range = 8.9–21.6 years; $N = 152$). The median age of the primiparous ex situ dams in our survey was 20.5 years (range = 12–24 years; $N = 10$: Table 1). These ex situ dams were significantly older at first parturition than the in situ dams, Wilcoxon test, $T = 1$, $P = 0.002$ (one-tailed test).

Neonatal Weight, Shoulder Height, and Foot Circumference of the Calf

The median shoulder height at birth was 88cm (range 79–112cm, $N = 10$; Table 1). There was no significant difference between the median height of the female calves (86.5 cm, $N = 6$) and the median height of the male calves (90.0, $N = 4$), Kolmogorov-Smirnov test, D (4, 6) = 0.67, $P > 0.10$.

The median birth weight of the calves was 107.5 kg (range 91–134 kg; Table 1). The difference between the birth weights of the male calves (median = 125 kg; $N = 5$) and the female calves (median = 104 kg; $N = 7$) was not statistically significant, Kolmogorov-Smirnov test, D (5, 7) = 0.657, $P > 0.10$. Neither the median weight at 3–5 days of age, 102 kg (Wilcoxon test, $T = 8$, $P >$

0.05; $N = 9$), nor the median weight at Days 12–13 of age, 103 kg (Wilcoxon test, $T = 9$, $P > 0.05$; $N = 8$) was significantly different from the median birth weight. By 31–32 days of age the calves ($N = 8$) had attained a median weight, 121 kg, significantly different from the median birth weight (Wilcoxon test, $T = 1$, $P = 0.016$). Although the calves' weights fluctuated during the first few weeks of life, they increased steadily at a mean rate of 0.90 kg/day (range = 0.58–1.32 kg/day) over then next 2 months. The mean period over which calf weight gains were measured was 69 days.

The surveys provided front and rear foot circumferences for only four calves (Table 1): Two female and two male. The foot circumferences were measured at the same time as the birth heights and weights, during the first 24 hr of life. The median front foot circumference was 45 cm and the median rear foot circumference was 47 cm.

Perinatal Management of the Dam and the Calf

The births of the calves were managed in similar ways (Table 2). All institutions treated their calves' umbilicuses with a disinfectant (iodine, Betadine®, Purdue-Frederick Norwalk, CT or Nolvasan®, Fort Dodge Animal Health Fort Dodge, IA) and collected blood samples from their dams for progesterone analysis, and 10 of the 12 dams were restrained during, and briefly after, parturition. Institutions separated the dam and the calf temporarily for 11 of the 12 births (Table 2). Apparently, these procedures were effective, because only four calves experienced umbilicus complications: One infected, two swollen, and one herniated (Table 2).

The dams exhibited a variety of birth positions: four standing, three crouching, two alternating between standing and laying on one side, one alternating between standing and crouching and one walking in circles. Only two births involved medical assistance (oxytocin or both estrogen and oxytocin).

Seven of the nine reintroductions to adults other than the dam involved only one adult at a time (Table 2). For half of the calves for which reintroductions were described (4/8), at least some of the adults were restrained (Table 2). Reintroduction of the dam to the calf occurred during the first few hours after birth (Median = 65 min: Table 3) whereas reintroductions to other members of the herd occurred considerably later (Median = Day 3: Table 3).

Eight of the 12 calves received nursing assistance: platforms were provided for six calves, the dam was steadied in one case, and the form of assistance for the eighth calf was not specified. Only three calves were bottle-fed at any time during the first 3 months of life (Table 2).

Timing of Events and Behaviors Related to Parturition

Table 3 shows the timing of several parturition-related events, and the times of the first observations of selected neonatal calf behaviors. Evidence of a dam's discomfort typically occurred only an hour or two before the birth (median = -1:32 hr). The bulge under the anus typically appeared only minutes before birth (median = -13 min). In our study, the term ‘‘genitals’’ referred to the inner lining of the urogenital tract for female calves and to the penis

Table 2. Behavioral and medical management of parturition

Intervention (survey question #: see Appendix A)	Yes	No
Treated calf's umbilicus with disinfectant (Q11)	12	0
Collected blood from dam for progesterone analysis (Q2)	12	0
Restrained the dam during labor and parturition (Q6)	10	2
Newborn calf temporarily removed from the dam (Q9)	11	1
Umbilicus complications: e.g., infection, hernia, swelling (Q12)	4	8
Dam standing at time of parturition (Q7)	5[a]	6[b]
Medical intervention to facilitate the birth: e.g., oxytocin (Q8)	2	10
Introduced calf to more than one elephant simultaneously (Q29)	2	7
Other elephants restrained while introduced to calf (Q30)	4	4
Handlers assisted calf's nursing: e.g., platform for calf (Q24)	8	4
Bottle-fed the calf at any time during the first 3 months (Q25)	3	9

[a]If one or more respondents did not answer a question, the sum of its "Yes" and "No" answers was fewer than 12.

[b]In three of these six cases, the dam was "crouching": front legs extended, rear legs bent, belly not touching the ground.

for male calves. A calf's genitals were down only minutes after a calf's birth (median = 20 min). The dam delivered the placenta within a few hours of birth. Eleven of the dams covered their calves with hay within the first few weeks of life (there was no survey response regarding the 12th calf; Table 3). Generally, temporal gland secretions, second teeth, and milk tusks were not observed during the first 3 months after birth.

First Observations of Selected Calf Behaviors

Table 4 shows the ages at which handlers first noticed certain calf behaviors. As in the wild, standing and walking occurred very early in life, typically within the first half hour. Rumbling and screaming usually occurred within the first 24 hr after parturition, although trumpeting was not observed until much later (median = 55 days). The calves typically exhibited some common ear movements, the headshake, earflap (one or both ears), and the two-ear extension (ear spread), during the first week of life.

In this study, the term ''aggression'' applied to threat displays (for example, ear spread with the head raised or trunk flicks toward the calf), pushing, striking, slapping, or grabbing the calf. Six out of the 12 dams were aggressive toward their calves and other adults were aggressive to all 11 calves for which the relevant question was answered. For 11 out of the 12 calves, an adult was reported to have wrapped its trunk around the calf's trunk (Table 4). This almost always occurred before the calf was 2 weeks old. There was no indication that any of the calves was harmed by the aggressive acts. Only one out of the nine calves ever exhibited aggression toward another elephant within the first 3 months.

The Calf's Use of its Trunk

Table 5 lists 17 behaviors involving a calf's trunk. Exploration with the trunk (sniffing or picking up objects, food, water and dung) developed in an orderly way in each case. For example, the median ages for sniffing or touching water, splashing water, taking water into the trunk, and

Table 3. Median time of observation of parturition-related events and physical development

Question	Median time since birth[a]			Range
	Female	Male	All calves	Earliest/latest
Cow discomfort	-0:2:05[b]	-00:30	-01:32	-138:05/-00:05
Mucous plug	-18:46 (4)[c]	-12:46 (4)	-15:01 (8)	-99:40/-04:24
Bulge	-00:10 (5)	-00:30	-00:13 (10)	-02:35/-00:03
Meconium	00:25	00:05	00:15	00:00/48:00+
Milk stool	Day 2 (6)	Day 5	Day 2.5 (11)	01:53/ > 1 month
Placenta expelled	02:38	03:52	02:55	01:12/16:59
First urination	03:30	02:00	02:35	00:06/>48 hr
Genitals[d] down	00:30	00:02	00:20	00:00/48:00
Genitals retract post-urination	< 1 month (5)	< 1 month (3)	~ 1 month[e] (8)	Day 18/not seen[f]
Reintroduce calf/cow	00:59 (5)	01:30	01:05 (10)	00:13/Day 1
Cow/calf unconstrained	Day 1	Day 3	Day 1.5	00:00/Day 13
First attempted suckle	01:35	< 12 hr (4)	02:37 (11)	00:58/Day 3
First successful suckle	03:40	07:24 (4)	03:40 (11)	02:10/Day 3
Cow helps calf nurse	Day 1	Day 2 (4)	Day 1 (11)	01:15/Day 17
Cow covers prone calf with hay	< 2 weeks (6)	< 2 weeks	< 2 weeks (11)	< 48 hr/<1 month
Calf separated from dam	Day 3 (3)	~ Day 8 (4)	Day 3 (7)	Day 1/2 weeks
Introduce calf/others	Day 1	Day 3 (4)	Day 3 (11)	00:00/Day 9
Cow/calf/others together	Day 9	Day 4.5 (4)	Day 8 (11)	Day 1/Day 48
Umbilicus healed	Day 11.5 (6)	< 2 weeks (3)	< 2 weeks (9)	Day 3/1 month
Foodpads slough	Day 62	Day 53	Day 58	<1 week/not seen
Temporal gland secretions	Not seen[f]	> 3 months	Not seen	Day 8/not seen
First teeth	Day 34	Day 21	Day 27	Day 3/not seen
Second teeth	Not seen (6)	> 2 months (4)	Not seen (10)	Day 79/not seen
Milk tusks	Not seen (6)	Not seen (3)	Not seen (9)	Not seen/not seen

[a] Times since birth are given in the formats “hours:minutes," days, weeks, or months, depending on the time scales used in the responses to the survey.

[b] Times before parturition are shown as negative numbers.

[c] (*n*) the number of subjects contributing to the median when it was not seven for the female calves or five for the male calves. The absence of a parenthesis indicates that all subjects in the category concerned contributed to the median.

[d]Genitals means the inner lining of the urogenital canal for females and the penis for males.

[e] “~”indicates that one of the responses used to calculate the median score used inequality symbols (< or >) to specify the time period during which a behavior occurred rather than specifying a particular day or time.

[f] “Not seen” indicates that the event was not observed within the first 3 months. We distinguished between an answer of ‘‘not observed’’ and the absence of any response to a question.

drinking water with the trunk were 5, 6.5, 17, and 56 days, respectively. Only four calves were observed dusting during the first 3 months of age, and most of them dusted only their stomach and sides. Only one calf dusted its back as well.

All 12 calves sucked their own trunks, typically starting within the first 2 days (Table 5). Eleven of the calves stepped on their own trunks, usually before 9 days of age (8/11 calves), and rolled their own trunk with a front foot, almost always during the first month (10/11 calves). The calves used their trunk together with a foot to pick up an object or to loosen soil relatively late in the survey period, between 1 and 3 months of age.

Table 4. First observations of behavioral events

Question	Median time since birth[a]			Range
	Female	Male	All calves	Earliest/latest
Stand	0:12	0:07	0:11	0:02/12:11
Walk	0:20	0:07	0:18	0:05/14:05
Run[b]	Day 2 (6)[c]	Day 2	Day 2 (11)	4:59/>2 week
Calf lays down to sleep/rest	05:30	11:19	06:35	02:40/Day 1
Rumble[d]	Day 1	Day 1 (4)	Day 1 (11)	0:10/not seen[e]
Scream[d]	Day 1	16:20	Day 1	<1:55/<48 hr
Trumpet[d]	Day 55 (6)	> 1 month (4)	Day 55 (10)	< 48 hr/not seen
Headshake	Day 1	Day 4 (4)	Day 1 (11)	0:10/Day 71
Ear flap	Day 8	Day 1 (4)	Day 2 (11)	3:30/not seen
Two-ear extension	Day 7	Day 15 (4)	Day 7 (11)	5:45/not seen
Calf > 5 m from dam	Day 7 (6)	~Day 9 (4)	Day 7 (10)	Day 2/Day 43
Swim[f]	>3 months	2 months	~2.5 months[g]	Day 9/not seen
Hay in stool	Day 60	Day 31 (4)	Day 60 (11)	Day 12/not seen
Rocks/sand in stool	>3 months (6)	>3 months	>3 months (11)	Day 44/not seen
Drink by mouth	Day 10	Day 8 (4)	Day 8 (11)	Day 1/not seen
Drink urine	Day 64 (4)	~Day 84 (2)	Day 80 (6)	Day 46/not seen
Dam to calf agression[h]	Not seen	<2 weeks	~8 days	<48 hr/not seen
Other adult to calf aggression[h]	Day 6	~8 days (4)	Day 6 (11)	<48 hr/<1 month
Adult pulls calf's trunk	<48 hr	<2 weeks	~Day 8	<48 hr/not seen
Calf to other aggression	Not seen (5)	Not seen (4)	Not seen (9)	<3 months/not seen
Foot used to dig soil	Not seen (5)	Day 24 (3)	~Day 54 (8)	Day 21/not seen

[a] Times since birth are given in the formats "hours:minutes," days, weeks, or months, depending on the time scales used in the responses to the survey.

[b] "Run" is a subjective term indicating, in effect, a fast walk.

[c] (*n*) the number of subjects contributing to the median when it was not seven for the female calves or five for the male calves. The absence of a parenthesis indicates that all subjects in the category concerned contributed to the median.

[d] "Rumble" refers to a group of sounds in which the low frequency components are most obvious. "Scream" refers to a high-pitched vocalization in which the higher frequencies are most obvious. "Trumpet" refers to a distinctive vocalization that appears to come from the trunk unlike "rumble" and "scream" that appear to come from the calf's head.

[e] "Not seen" indicates that the event was not observed within the first 3 months. We distinguished between an answer of "not observed" and the absence of any response to a question.

[f] The first episode of swimming was partly determined by the nature of the exhibit and the management style.

[g] "~"indicates that one of the responses used to calculate the median score used inequality symbols (< or >) to specify the time period during which a behavior occurred rather than specifying a particular day or time.

[h] "Aggression" is a term that included pushing another elephant, threatening another elephant by a two-ear extension or other behaviors, grabbing another elephant's trunk, or the aggressor using its trunk to strike another elephant.

Table 5. First observations of calf using its trunk

Question	Median time of observation[a]			Range
	Female calves	Male calves	All calves	Earliest/latest
Calf sucks own trunk	Day 2	Day 2	Day 2	0:46/<2 weeks
Calf steps on own trunk	Day 4	<2 weeks	Day 7	18:00/not seen[b]
Calf rolls own trunk with foot	Day 14	Day 23	Day 19	Day 6/not seen
Calf sniffs or touches an object	Day 1	<21 hr	Day 1	3:30/Day 2
Calf picks up an object	Day 4	Day 2	Day 3.5	Day 2/<2 weeks
Calf sniffs or touches food	Day 2	Day 2	Day 2	15:45/Week 3
Calf places food in its mouth with trunk	Day 11	Day 10	Day 10.5	Day 3/Day 50
Calf uses trunk tip to gather food	Day 90 (5)	~Day 57 (2)	Day 90	Day 12/not seen
Calf sniffs or touches water	Day 4	Day 6	Day 5	5:45/not seen
Calf splashes water	Day 7	Day 6	Day 6.5	18:10/not seen
Calf sucks water into trunk	Day 14	Day 37	Day 17	Day 2/not seen
Calf drinks using trunk	<3 months (5)	Day 41 (4)	Day 56 (9)	Day 1/not seen
Calf sniffs or touches dung	Day 2	32:45	Day 2	20:05/Week 3
Calf brings rocks or sand to mouth	Day 37 (6)	Day 43	Day 38	Day 3/not seen
Calf picks up object with trunk and foot	Not seen (5)	~Day 61 (4)[cd]	<3 months (9)	Day 2/not seen
Calf digs soil with trunk and foot	Day 62 (3)	Day 24 (3)	Day 43 (6)	Day 21/not seen
Calf dusts	Not seen (4)	<3 months (4)	~3 months (8)	<3 months/not seen

[a] Times since birth are given in the formats "hours:minutes," days, weeks, or months, depending on the time scales used in the responses to the survey.

[b] "Not seen" indicates that the event was not observed within the first 3 months. We distinguished between an answer of "not observed" and the absence of any response to a question.

[c] "~" indicates that one of the responses used to calculate the median score used inequality symbols (< or >) to specify the time period during which a behavior occurred rather than specifying a particular day or time.

[d] (*n*) the number of subjects contributing to the median when it was not seven for the female calves or five for the male calves. The absence of a parentheses indicates that all subjects in the category concerned contributed to the median.

Discussion

All 12 of the calves in our study were born at night. This is consistent with Moss's [1988] suggestion that, as observations of calf births in situ are so rare, most calves must be born at night.

According to the results of the survey, there is a relatively standardized procedure for managing the birth and early development of an African elephant calf: Taking blood samples from the dam to measure progesterone levels, restraining the dam, disinfecting the umbilicus, and separating the dam and the calf for a brief period. The calf usually is reintroduced to the dam within hours of birth and introduced to the other elephants at the facility within days of parturition. As many have reported for African elephant births in situ, the dams usually showed discomfort only within hours of parturition. Szdzuy et al. [2006] have described behavioral and endocrinological changes in three pregnant elephants, concluding that the endocrinological measures predicted parturition more reliably.

As numerous authors have reported for both calves in captivity [Andrews et al., 2005; Bercovitch and Andrews, 2008; Berg, 1987; Olson, 2004; Schwammer, 2002; Styles, 1982] and in situ [Lang, 1967; Leuthold and Leuthold, 1975; McKnight, 1992; Moss, 1988; Vyas et al., 2005], the calves in the current survey stood and walked within an hour after birth and successfully nursed within the first few hours. The mean gestation period of 640 days was shorter than most previous estimates, although gestation estimates for African elephants have varied considerably across sources: 642 days [Oerke et al., 2006], 659 days, 657 days [Meyer et al., 2004], 656 days [African elephants in situ: Moss, 1988], 22 months [Allen, 2006], 92 weeks [Schmidt, 1999], and 20–22 months [Emanuelson, 2006]. It is possible that the short pregnancies of captive elephants result from the availability of veterinary care and a highly nutritional diet, although there is no direct evidence regarding this suggestion. Although the mean gestation lengths of male and female calves did not differ significantly, the mean gestation period was typically longer for females than for males, as other studies [Meyer et al., 2004; Oerke et al., 2006] have reported.

As with the estimates of the length of gestation, estimates of the average birth weight of African elephant calves vary. Emanuelson [2006] estimated the weights of newborn calves to be between 100 and 120 kg, without specifying a sex difference, whereas Niemuller et al. [1999] estimated birth weights to be about 120 kg for male African elephant calves and about 90 kg for female African elephant calves. Emanuelson [2006] also estimated the typical height of a newborn elephant calf to be about 0.9 m. The male and female newborn calves in our study did not differ significantly in weight or in height, although both differences approached statistical significance. The median height (88 cm) and weight (106 kg) of the calves in our study fell within the ranges specified by Emanuelson [2006] and Niemuller et al. [1999]. Although numerous researchers have used Von Bertalanffy growth curves to estimate the ages of African elephants from shoulder heights and weights [Hanks, 1972; Laws and Parker, 1968; Shrader et al., 2006], such curves are not useful for predicting birth height or birth weight. The estimates generated by such curves vary widely: For example, Shrader et al. [2006] indicated that such growth curves predicted the heights of newborn African elephant calves to be between 86 and 253 cm. Consistent with Olson's [2004] estimates, the calves typically lost several kilograms immediately following parturition, but then gained about 1% of their initial body weight per day.

Neonatal Behaviors

The ages of first standing and walking were consistent with observations in situ [McKnight, 1992; Moss, 1988; Poole, 1996; Vyas et al., 2005] and with previous reports concerning captive animals [Andrews et al., 2005; Bercovitch and Andrews, 2008; Leuthold and Leuthold, 1975; Theison, 1999]. The median ages at which the calves first attempted to nurse (02:37 hr) and first suckled successfully (03:40 hr) were also similar to those others have observed in situ [Moss, 1988; Vyas et al., 2005] and in captivity [Andrews et al., 2005; Theison, 1999]. Similarly, more detailed studies have reported the same neonatal calf vocalizations recorded in the surveys: rumbling and screaming [Berg, 1983, 1987; Poole, 1994; Stoeger-Horwath et al., 2007], although Stoeger-Horwath et al. [2007] used the term ''roaring'' for what we have called ''screaming.'' The time at which the first teeth (premolars) appeared, median = 27 days (range = 3 days–''not seen''), resembled the limited data available from individual animals: 11–27 days [Bolwig et al.,

1965] and 43–65 days [Lang, 1980]. The development of the captive calves, in terms of these developmental milestones, was comparable to that of calves in situ.

The handlers at every institution observed several behaviors directed by an adult toward the calf. One common behavior in our study, the dam covering a prone calf with hay, was similar to behaviors reported in situ: That is, a dam covering its calf with hay or dirt [Leuthold and Leuthold, 1975; McKnight, 1992; Moss, 1988; Nicholson, 1952; Spinage, 1994], though the motivation for this behavior is unclear. Perhaps the dam is protecting the calf from predators or sunlight by covering it, keeping the calf warm at night (when most calves are born), or all three. The predator and warmth hypotheses seem more likely, given that most calves are born at night [our data; Moss, 1988].

An adult elephant grabbed the calf's trunk for 11 out of 12 calves, usually within the first 2 weeks of life. In almost every case, at least one adult was aggressive toward the calf, threatening, slapping, or pushing the calf. However, other researchers have reported similar types of aggression by adults toward calves in situ [Douglas-Hamilton and Douglas-Hamilton, 1975; Spinage, 1994] and in captivity [Borragan and Gallego, 1998; Berg, 1987; Stoeger-Horwath et al., 2007], and trunk pulling in captivity [Berg, 1987].

Trunk Use

The captive calves began to exhibit various components of drinking (drinking by mouth, splashing water, sucking water into the trunk, placing water in the mouth with the trunk), examining dung, manipulating objects, digging and dusting on a developmental schedule similar to that of African elephant calves in situ [Bolwig, 1965; Moss, 1988] and that reported previously for captive calves [Berg, 1987]. Consistent with observations obtained in situ [Bolwig, 1965; Douglas-Hamilton and Douglas-Hamilton, 1975; Moss, 1988; Spinage, 1994] and in captivity [Berg, 1987; Lang, 1967], all of the calves sucked their own trunks very soon after parturition, usually within the first 2 days. Several researchers have compared this behavior with thumb sucking by human infants [Bolwig, 1965; Douglas-Hamilton and Douglas-Hamilton, 1975; Spinage, 1994], arguing that in both cases, the behavior comforts the young animal. Finally, Berg [1987] noted that the captive elephant calves in her study stepped on their own trunks. The calves in our study stepped on their own trunks and used a foot to roll their own trunks. Although such behaviors might result from the calves exhibiting lower levels of motor control and stability than adult elephants, all four calves in Indianapolis appeared to perform these behaviors systematically and in an exploratory manner.

Conclusions

Overall, the birth process for the calves in this study was managed consistently and well, and the neonatal calves behaved like African elephant calves in situ. Labor and delivery occurred quickly and without complications. A few behaviors, such as calves sucking their own trunks, dams burying their calves under hay, and adults pulling a calf's trunk have rarely been reported in captivity but, in fact, similar behaviors occur in situ. The gestation period for captive dams

appeared to be shorter than gestation periods observed in situ. The postneonatal behavioral development of captive calves occurred systematically, much like that observed for calves in situ, and the calves attained developmental milestones concerning trunk use and locomotion at about the same times as calves in situ.

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Appendix A

Calf Survey 2000–2006

The four surveys (S1, S2, S3 and S4) addressed 4 time periods: Pre-birth to 48 hours (S1), 48 hours to 2 weeks (S2), 2 weeks to 1 month (S3), and one to three months of age (S4). For ''When'' questions, Surveys 1 and 2 asked for a date and a time. Surveys 3 and 4 asked only for a date. We have listed similar questions together. We have listed the surveys that included any particular question after that question. We sometimes asked whether an event had first occurred during the time period covered by a survey. Respondents could enter ''already occurred'' (AO) if an event or behavior had been reported on a previous survey, ''has not occurred'' (HNO) for an event under the staff's control (for example, reintroduction of the calf to other elephants), or ''have not observed'' (HNO) for an event outside of the staff's control (For example, passing the meconium).

1. Demographic information: Date and time of birth, Source, Sex. S1
2. Did you collect blood from the mother before birth and have it analyzed for progesterone? S1
3. When did you observe the mucous plug pass? S1
4. When did you first observe signs of discomfort? S1
5. When did the bulge first appear? S1
6. Was the mother restrained during the labor and birth–If yes, by what method? (Chains, ERD, etc.)? S1

7. What position was the mother in at the time of birth? Standing, Crouching (Back legs bent; front legs extended), Stretching (On belly with front and back legs bent), Laying on one side, or other). S1
8. Did you require any medical assistance in order to speed up the birth process (e.g. oxytocin)? (If yes, please describe:) S1
9. Did you pull the calf away from the mother after the birth? S1
10. When did the mother pass the placenta? S1
11. Did you treat the umbilicus of the calf in this time period? Yes/no. If yes, by what method and how often? S1, S2, S3, S4.
12. Did you experience any difficulties with the umbilicus (examples: infection, hernia, etc.) during this time period? Yes/no. If yes, please describe? S1, S2, S3, S4
13. When did you observe that the umbilicus had healed completely? S2, S3, S4
14. If you measured the height of the calf at the shoulders in this time period, please give the measurement (indicate whether in inches or centimeters). (Table for multiple measurements?) S1, S2, S3, S4
15. If you weighed the calf in this time period, please give the date, time (if known) and weight (indicate whether in pounds or kilograms). (Table for multiple measurements) S1, S2, S3, S4
16. If you measured the foot circumference (foot planted or from footprint) of the calf in this time period, please give the measurement (Indicate whether inches or centimeters). (Date time; which foot?) (Options were left front, left rear, right front or right rear foot, or "did not measure") S1, S2, S3, S4
17. When did you first observe the genitalia of the calf hanging out? S1
18. When did you first observe the calf urinate? S1
19. When did you first observe the calf's genitalia retracted after urination? S4
20. If you separated the calf and mother, when did you begin the re-introduction? S1, S2, S3, S4
21. When were the calf & mother first allowed unrestricted contact? S1, S2, S3, S4
22. When did you first observe the calf attempt to nurse/suckle from the mother? S1, S2, S3
23. When did you first observe the calf nurse successfully from the mother? S1, S2, S3, S4
24. Have you had to assist the calf in nursing in this time period because he/she could not reach? (e.g., place a stool for the calf to nurse) Yes/no. If yes, please describe: S1, S2, S3, S4
25. Have you had to bottle feed the calf in this time period? Yes/no. S1, S2, S3, S4
26. When did you first observe the mother perform an ACTIVE cooperative response to nursing (e.g. moving foreleg forward)? S1, S2, S3, S4
27. Have you observed the mother cover the calf with hay while the calf is laying down in this period? Yes/no, describe: S2, S3, S4.
28. When did you begin introducing the calf to the other elephants? S1, S2, S3, S4
29. When introductions to other elephants began, how many elephants were introduced at one time? S4
30. When introductions to other elephants began, were the adult elephants restrained? If yes, how? S4
31. When were mother, calf and any of the other elephants (or group) first allowed unrestricted contact? S1, S2, S3, S4

32. Have you observed any aggression toward the calf by the mother in this time period? Yes/no, describe: S1, S2, S3, S4.
33. Have you observed any aggression toward the calf by an adult other than the mother in this time period? Yes/no, describe: S1, S2, S3, S4.
34. Have you observed any adult grab and pull the calf's trunk with his/her own during this time period? Yes/no, describe: S1, S2, S3, S4.
35. Have you observed any aggression from the calf toward any of the other elephants during this time period? Yes/no, describe: S4.
36. When did you first observe the meconium (first stool) from the calf? S1
37. When did you first observe milk stool from the calf? S1, S2, S3
38. When did you first observe the calf stand? S1
39. When did you first observe the calf walk? S1
40. When did you first observe the calf "run"? S1, S2, S3
41. When did you first observe the calf laying down to sleep? S1
42. When did you first hear the calf rumble? S1, S2, S3, S4
43. When did you first hear the calf scream? S1, S2, S3, S4
44. When did you first hear the calf trumpet? S1, S2, S3, S4
45. When did you first observe the calf perform a headshake? S1, S2, S3, S4
46. When did you first observe the calf flapping his/her ears? S1, S2, S3, S4
47. When did you first observe the calf spread both ears? (Full extension) S1, S2, S3, S4
48. When did you first observe the calf suck his/her own trunk? S1, S2, S3, S4
49. When did you first observe the calf step on his/her own trunk? S1, S2, S3, S4
50. When did you first observe the calf roll his/her trunk with his/her foot? S1, S2, S3, S4
51. When did you first observe the calf touch an object with his/her trunk? S1, S2, S3
52. When did you first observe the calf pick up an object with his/her trunk? S1, S2, S3, S4
53. When did you first observe the calf touch or sniff food with his/her trunk? S1, S2, S3, S4
54. When did you first observe the calf put food in his/her mouth? S2, S3, S4
55. When did you first observe the calf use the tip of his/her trunk to gather food? S4
56. When did you first observe the calf putting dirt or sand in his/her mouth? S2, S3, S4
57. When did you first observe the calf putting rocks in his/her mouth? S2, S3, S4
58. When did you first observe the calf sniff or touch dung with his/her trunk tip? S1, S2, S3, S4
59. When did you first observe the calf drink water by mouth (independent of trunk)? S1, S2, S3, S4
60. When did you first observe the calf sniff or touch water with his/her trunk? S1, S2, S3, S4
61. When did you first observe the calf splash water with his/her trunk? S1, S2, S3
62. When did you first observe the calf sucking up water with his/her trunk? S2, S3, S4
63. When did you first observe the calf successfully drink water from trunk (empty water into mouth)? S4
64. When did you first observe the calf drink urine? S4
65. When did you first observe the calf using the tip of his/her trunk to loosen soil? S4
66. When did you first observe the calf using his/her foot and trunk together to pick up an object? S4
67. When did you first observe the calf using his/her foot and trunk together to loosen soil? S4

68. When did you first observe the calf more than 5 meters from his/her mother? S2, S3
69. When did you first observe pieces of hay in the calf's stool? S2, S3, S4
70. When did you first observe that the first set of teeth had cut through the gum? S1, S2, S3, S4
71. When did you observe that the second set of teeth had cut through the gum? S4
72. When did you first observe the milk tusks cut through the sulcus? S4
73. When did you first observe rocks in the calf's stool? S2, S3, S4
74. When did you first observe sand or dirt in the calf's stool? S2, S3, S4
75. When did you first observe the calf's footpads begin to slough off? S2, S3, S4
76. When did you first observe a temporal gland secretion? S1, S2, S3, S4
77. When did you first observe the calf swimming? S1, S2, S3, S4
78. Have you observed the calf dusting? Where? S4

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