CASE STUDY: RELATIONSHIP BETWEEN WEIGHT GAIN AND OFFSPRING SEX IN AFRICAN BUSH ELEPHANTS (*LOXODONTA AFRICANA AFRICANA*) AT THE SAN DIEGO ZOO SAFARI PARK

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Abstract

Facing a male biased offspring sex ratio (7:4) in the African bush elephant (*Loxodonta africana africana*) population at the San Diego Zoo Safari Park (SP), the overall weight and weight gain of the breeding females was analyzed and the weight gain prior to calf conception was determined. The breeding females arrived at the SP heavier than similarly aged Zambian female elephants used as a comparison. The females remained heavier and gained more weight than the Zambian females over the 10 years at the SP. Despite the male biased offspring, the sex ratio in this small population is not different than 50:50 ($X^2 = 0.818$; df = 1; $P = 0.40$). There was no difference in the weight gain of breeding females 6 mo or 1 year prior to conception on the resulting sex of calf. Further monitoring of weight gain trends and offspring sex ratio needs to be done to determine if weight gain prior to conception influences calf sex. Additionally, monitoring body weight and body condition of the breeding female elephants at the San Diego Zoo Safari Park ensures a healthy reproductive live and preventing obesity.

Introduction

Based on the Trivers and Willard hypothesis, it is suggested that the nutrition can influence the sex of the offspring.[6] Berkeley and Linklater suggested that a decrease in caloric intake, to an energy neutral or negative balance before conception and during early gestation would have a possible negative correlation with the male offspring sex ratio in black rhinoceros (*Diceros bicornis*).[1] Here we provide data on the male-biased sex ratio (7:4) of the African bush elephants (*Loxodonta africana africana*) at the San Diego Zoo Safari Park (SP) over the past 10 years. The goal of this study was to evaluate the weight gain of the adult female elephants since their arrival to the SP and compare them to elephants in the wild, and to evaluate if weight gain during the year before conception influenced the sex ratio of the offspring.

Methods

The herd evaluated consisted of six female African bush elephants that arrived at the SP in 2003. Each of the females has given birth to at least one calf since being at the facility. The total number of births has been 12, but only 11 were conceived at the SP, and 11 are still alive. Animals have been weighed at least monthly since their arrival.

The age of each dam at arrival to the institution was calculated using the individual's estimated birth date. Based on this information the average weight during defined age periods (11-14, 14-

17, 17-20, and 20-23 years of age) was calculated for each female. The average of all six females was compared to that of wild breeding and nonbreeding elephants in Zambia (Table 1).[3] The first age period only included data collected at the SP, therefore for five of the six females this period was less than six months. Average weight gains over the same age were also compared to weight gain of Zambian elephants (Table 2).[3]

Using the date of birth of the first calf, the age of the dam at birth of each calf was calculated. Using the average gestation time for African bush elephants of 22 mo, the estimated date and age of the dam (in years) at the time of conception was calculated.[5] Based on the estimated date and age of conception the weight gains 6 mo and one year prior to conception were calculated for each calf born (Table 3). This table does not include the first born calf of dam #2, since it was conceived prior to arrival at the SP

A chi-square analysis was done to determine if the sex ratio of the calves (7 males:4 females) conceived at the SP was different then 50% of each sex. An unpaired student t-test, assuming un-equal variance (Microsoft Excel) was used to determine if the weight gain prior to conception was different for male and female calves.

Results and discussion

Average body weights of the females in the SP herd were 41-45% greater than free-ranging elephants in Zambia at similar ages (Table 1).[3] During the first 3 age periods, the SP females gained 17-99% more weight during the three 3-year periods than Zambian females (Table 2). During the 20-23 yr of age period, the SP and Zambian females had similar weight loss. The elephants arrived at the SP heavier than the Zambian female elephants at the same age and continued to gain weight at a greater rate through 20 years of age. The greatest weight gain occurred between 14 and 20 years of age when 9 calves were born. The great gain in body weight may also be due to the lack of environmental pressures such as rainfall influencing the availability of food in the SP population. This may have greater implications during periods of growth than when the animal is fully grown.

Despite a male sex bias at the SP, the ratio is not statistically different than 50:50 in this small population ($X^2 = 0.818$; df = 1; P = 0.40). There was no difference between the average weight gain of dams during the 6 mo (P = 0.53) or one year (P = 0.86) prior to conceiving female or male calves (Table 4).

Trivers and Willard proposed that for most large mammals the male sex is the more costly and therefore should be favored by females with higher body condition.[6] Based on this hypothesis, dams that gained more body weight prior to conception would have male calves. This was not the case in this study. Many other factors that could possibly affect the sex-ratio have to be taken into consideration. These can include a difference in food composition, such as a higher fat content as shown with ruminants by Green et al. where a higher fat content in the diet may induce a male biased sex-ratio; and the population density.[2] African elephants housed in relatively small enclosures compared to natural environments may be more inclined to skew the sex ratio towards the dispersing sex, more specifically, males, as was shown with red deer by Kruuk et al.[4]

Further monitoring of weight gain trends and offspring sex ratio needs to be done to determine if weight gain prior to conception influences offspring sex. Additionally, monitoring body weight and body condition of the elephant cows at the San Diego Zoo Safari Park ensures a healthy reproductive live and preventing obesity.

Literature cited

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Table 1. Average weights over given age periods of non-pregnant and pregnant African bush elephants (*Loxodonta africana africana*) at the San Diego Zoo Safari Park compared to free-ranging African elephants.

	Average weight (kg)			
Animal	**11-14 yr**	**14-17 yr**	**17-20 yr**	**20-23 yr**
Dam #1	1926	2270	2832	2918
Dam #2	2169	2270	2832	2902
Dam #3	1736	2076	2769	3135
Dam #4	1778	2228	2555	2845
Dam #5	1957	2404	2785	2940
Dam #6	1503	1843	2083	2332
Average	1845	2182	2643	2845
Free-ranging breeding and non-breeding African elephants[1]	1272	1549	1830	1957
Difference	573	633	813	888

[1] Hanks, J. 1972. Growth of the African elephant (*Loxodonta Africana*). East Afr. Wildl. J. 10:251-272.

Table 2. Average weight gain over given age periods of non-pregnant and pregnant African bush elephant (*Loxodonta africana africana*) at the San Diego Zoo Safari Park compared to free-ranging African elephants.

	Average weight gain (kg)			
Animal	**11-14 yr**	**14-17 yr**	**17-20 yr**	**20-23 yr**
Dam #1	100	732	264	-126
Dam #2	603	122	602	-50
Dam #3	174	632	816	-174
Dam #4	510	616	400	190
Dam #5	487	862	-44	56
Dam #6	48	374	262	-16
Average	320	556	383	-20
Free-ranging breeding and non-breeding African elephants[1]	274	280	281	-26
Difference	46	276	102	6

[1] Hanks, J. 1972. Growth of the African elephant (*Loxodonta Africana*). East Afr. Wildl. J. 10:251-272.

Table 3. Time frame of non-pregnant, lactating, and non-lactating African bush elephants (*Loxodonta africana africana*) with total and yearly weight gain of that time period and the sex of the calf.

Animal	Date of Birth of Calf	Estimated date of conception	Weight gain prior to conception (kg)		Sex of the calf
			6 months	1 year	
Dam #1	9/19/2007	11/28/2005	243	264	F
	5/12/2010	7/21/2008	101	-230	M
Dam #2	2/23/2004	5/4/2002			M
	2/14/2010	4/25/2008	24	27	M
Dam #3	4/12/2010	6/21/2008	62	118	M
	8/28/2012	11/7/2010	14	-182	F
Dam #4	9/11/2006	11/20/2004	81	79	F
	3/13/2009	5/23/2007	6	1	M
	9/26/2011	12/5/2009	-22	98	M
Dam #5	3/12/2007	5/21/2005	168	271	M
	12/27/2010	3/7/2009	-59	-101	M
Dam #6	11/28/2007	2/6/2006	-25	22	F

Table 4. Comparison of average weight gains of dams one year and six months prior to conception between male and female conceptions, variance and t-test analysis.

Weight gain (kg) prior to conception	Female	SD[1]	Male	SD	T-test
6 months	79	118.3	40	77.1	0.53
1 year	46	183.6	26	161.2	0.86

[1]Standard deviation.