Effects of Group Size and Composition on Interactive Behaviors of Wild African Elephants in Tarangire National Park

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The African elephant, or Loxodonta africana, is an extremely intelligent animal whose relationships are effected by multi-faceted variables that are not currently well understood. I wished to determine whether certain aspects of group composition, such as group size and age class, affect the prevalence of affiliative, aggressive, or submissive behaviors. Elephants were observed for approximately 4 weeks in Tarangire National Park in order to more accurately understand the factors directly affecting elephant interactions. Individual groups were watched for up to one hour, and notes were taken on group size and composition. Interactions between elephants of the same group were recorded using continuous sampling. Using percentages and confidence intervals for significance, I found that the highest prevalence of interactions among young elephants are affiliative and with adult cows. As they grow to adolescence and adulthood, a higher percentage of their interactions are aggressive and submissive. Bull groups showed the highest percentage of aggression and submission, and thus adult gender seemed to be the greatest factor in determining interaction type frequencies. An increasing group size was also correlated with a higher frequency of aggression and less frequent affiliative behaviors. By more fully understanding the complexities influencing how elephants interact with each other, those working to preserve the species can make informed choices that allow populations to reach maximum densities and maintain healthy interactions with their ecosystem.

Introduction

African elephants are highly intelligent, highly social animals capable of incredibly complex and transient relationships spanning several generations. They live in matriarchal groups consisting of a female and her offspring, and sometimes the matriarch's sisters and their offspring. At maturity, males disperse from their parent herd, either becoming solitary or forming loose associations with other males. Herd sizes average around 10 to 20 individuals, though sometimes groups can reach up to 50 (Dorst, 1970). However, when groups become too large, they may split off and form "bond groups" in which loose association is maintained. Such is the bond strength between

individuals and bond groups that even after short periods of separation, elephants express great excitement upon meeting again. They run towards each other, touching trunks and rumbling in what could be interpreted as joy (Cohn, 1990).

However, intense slaughter by poachers seeking ivory has had a profound effect on elephant populations and, consequently, their social relations. Where populations in Africa once reached several hundred million, today there are less than one million. Currently, elephants are classified as a red list vulnerable species (Blanc, 2008). Poaching has been shown to have long-term negative effects on elephant populations, such as disrupting kin-based association patterns, decreasing the quality of social relationships, and increasing male reproductive skew due to a lack of older males available to reproduce (Archie and Chiyo, 2012). Because tusk size is correlated with age, older elephants are often targeted specifically. This is especially problematic as dominance is determined by seniority, so poaching results in the disruption of herd hierarchies.

Today, Tarangire National Park in Northern Tanzania remains an essential habitat for African elephants, providing an important water and food source during the dry season. Populations there have continued to increase at about 7% per year (Foley and Faust, 2010) putting the number of animals in the park at approximately 5,500 individuals. While this is much better than the 1960's record minimum of 440 animals (Foley et al., 2001), this is far lower than numbers reached in the past. Much work must still be done to ensure elephants have a lasting future. Because of the complicated nature of elephant interactions, it is important to understand the factors influencing elephant behavior in order to more accurately predict how environmental changes and human interference will affect their conservation. However, there remains a significant gap in knowledge about direct effects of elephant social behavior.

This research aims to examine the effects of group size and composition on the interactive behaviors of wild African elephants. Do larger group sizes result in more aggressive behavior exhibitions, or more cooperative behaviors? How does age class affect the type of interactions exhibited? How do these factors differ in their effects between matriarchal groups and all male groups? I hypothesized that as group size increased there would be a higher prevalence of aggression due to dominance maintenance. Due to the more aggressive tendencies of bull elephants, I also hypothesized that all-male groups would show more aggressive behaviors than matriarchal groups. If clear correlations can be found between the many factors that influence group behavior and the interactions between elephants, a deeper understanding of elephant behavior will be attained and aid in the conservation of the species.

Methods

All data was collected within Tarangire National Park, Northern Tanzania. Preliminary observations and behavior classification began on October 17th. Main data collection was performed between October 21st and November 9th, nearing the end of the dry season. During this time elephants

congregate largely in Tarangire due to water limitations. Data was collected almost every day for 3-7 hours depending on weather conditions, roughly between 6 to 11:30 AM and 4 to 6:30 PM. At high noon it became too hot for much activity, and elephants mostly stood or slept in the shade. We drove along the safari roads in the northern half of the park until an elephant herd was located. Date, time of day, weather, and habitat were all recorded, as well as group size and age classes within the group. If gender could be determined it was noted as well. Elephant behavior was recorded using continuous sampling, recording only interactive behaviors. With the help of binoculars, each group was watched for 60 minutes, and every interaction between 2 elephants was recorded, along with the time of occurrence, the age class, and if possible, the gender of the individuals interacting. Age was determined by relative size, where young were approximately 1/3 the size of an adult cow, and an adolescent approximately 2/3 the size of an adult cow. Gender was mainly determined by head shape and tusk length, where bulls have rounder skulls and longer tusks in proportion to body size, and cows have more angular foreheads. This method is mostly viable for adult elephants; thus adolescents were only able to be sexed half the time and young were not able to be consistently sexed. Behavior was classified using an ethogram compiled from my own observations and classifications presented by Estes (1991), as well as by a previous ACM student (O'Neil, 2004). In order to minimize observer interference, elephants were observed at least 30 meters away, preferably between 50-100 meters. However, complete elimination of this problem was impossible due to viewing limitations that accompany large distances, and this is noted in data interpretation. If the elephants moved out of sight before the 60 minutes concluded, observation terminated and time was noted.

Data analysis was performed by averaging interaction types overall between varying age classes and group sizes. To test for statistical significance, confidence intervals were calculated by dividing the standard deviation by the square root of the data set. Confidence intervals are shown as error bars in the Figures section.

Results

A total of 42 matriarchal groups and 7 all-bull groups were recorded, making the sample size 555 elephants. Female group size varied greatly between 3 and 52 individuals, with an average group size of 9.9 SD +/- 7.56. Bull group size ranged from 3 to over 18 with an average group size of 10.57 SD +/- 5.79, though due to the fluid nature of bull groups such numbers were difficult to accurately ascertain.

In matriarchal groups, young initiated 54.4% of interactions. A high percentage of these interactions were with adult cows (80.2%), and nearly all were affiliative in nature (95.7%). Cows and adolescents had relatively the same percentage of total interactions (24.9% for cows, 20.7% for adolescents). Cows interacted with other cows 46.3% and with young 32.6% of the time, while adolescents interacted with cows 58.9% and with young 24.0% of the

time. For both cows and adolescents the majority of interactions were affiliative, though while 82.3% of adolescent interactions were affiliative and 13.8% aggressive, cows showed a higher degree of aggressive interactions with 69.0% affiliative and 26.1% aggressive. In bull groups, aggressive interactions totaled 49.1%, affiliative interactions totaled 32.1%, and submissive interactions totaled 14.8%. Sexual interactions were also observed at 4.1%, though all sexual behavior was witnessed during one observation session in which bulls were bathing and in an excited state.

Group size was also analyzed as a potential factor for interaction type prevalence within matriarchal groups. Because of the smaller bull-group sample size, they are not included in this section of analysis. Groups were organized into sections of 2-5, 6-10, 11-15, and over 16 individual elephants per group. For affiliative interactions the confidence interval was 1.29%. There was a significant difference in groups with 2-5 elephants, in which affiliative interactions were highest at 92.8%. Aggressive interactions were significantly lower in groups of 2-5 with a percentage 5.4% and a confidence interval of 1.31%. Aggression was highest in groups of >16 individuals with a percentage of 11.5%, though not as strongly significant. Submissive interactions suggest an increasing prevalence as group size increases, but the only clearly significant data is the drop in prevalence at <16 individuals with a percentage of 1.0% (confidence interval 0.33%).

Discussion

The average group size of approximately 10 elephants found in Tarangire National Park was consistent with typical average group size among African elephants. However, the maximum group size of 52 elephants was far above this average, resulting in the large standard deviation of 7.56. It is interesting to note that a large bull group of varying numbers up to >18 individuals would congregate every day in the same patch of dry riverbed. Records of such high number are not often heard of, and more research in this area could potentially produce groundbreaking results. It suggests that male elephants are potentially far more social than is known.

In matriarchal groups, young elephants initiated the majority of interactions, with adolescents and adults initiating basically the same percentage of interactions. Most of these interactions were with adult cows, and almost all of them were affiliative in nature. These interactions are most likely often with the young's mother, as many such interactions involve breast-feeding. Trends suggested that as the elephant ages, a higher percentage of interactions become aggressive or submissive, and interactions with adolescents and young become more common. In adolescence, the majority of interactions still take place with adult cows; however the interaction with younger calves increases, and aggressive and submissive interactions increase, as well. In adult cows these trends become even more prominent. In non-first order relationships in the Amboseli ecosystem, agonistic interactions between elephants occur at very low frequency (0.05 ±0.01 per hour, Archie et al. 2006). While affiliative in-

teractions are still over half of all interactions performed by adult cows,　almost 1/3 of such interactions were found to be aggressive. As predicted, the most prevalent interaction type between bulls was aggressive. In fact, bulls were the only group to have a higher percentage of aggressive interactions than affiliative interactions, as well as showing the lowest frequency of affiliation and highest frequency of submission. I was a little surprised to observe some sexual behavior as well, though they were only observed between fellow bulls. It is possible that such behaviors act not only as practice mating rituals, but that they also work to preserve dominance hierarchies.

When group size was analyzed as a function of interaction frequency, it was found that smaller groups displayed a higher percentage of affiliative interaction and lower aggressive interactions. This is possibly due to the composition of smaller groups, which often consist of a singular female and her offspring, and the majority of mother to young interactions were affiliative. Aggressive interactions also seemed to increase with increasing group size, though curiously enough submissive behavior was lower in group sizes of >16. This is possibly due to the overall higher degree of aggressive behavior in very large groups, where aggression is more likely to be reciprocated with aggression. However, this is not as statistically significant as other trends seen. Overall, the greatest factor in determining the frequency of interaction types was gender. While this mostly applied to adults, the trend was seen even within matriarchal groups, where adult cows often showed more aggressive behavior to adolescent males than adolescent females, especially when the adolescent approaches her young.

There were several limitations in data collection that posed a challenge. Due to time constraints, only elephants in the north of Tarangire National Park were sufficiently recorded. Not all elephant groups could be observed for a full hour as they are often on the move, and sometimes members of a group were concealed by foliage or other elephants. Another complication was the sheer numbers of elephants that made Tarangire ideal for research in the first place. Because it is a time for intense elephant congregation, groups that normally would not interact may be seen in close proximity, and it is difficult to determine actual group sizes. This hindrance can partially be resolved because of their tendency to clump in their family group even when near another herd. It is typically easy to determine the matriarch of a group because of her size, and that all other elephants will follow her once she begins to move. Another challenge was the affect that the closeness of our vehicle as well as other tourist vehicles had on elephant behavior. Even when parked far away, other vehicles would often approach well beyond a comfortable distance from the elephants and disturb them. Reactions obviously directed at safari vehicles were not recorded, though it is possible results were still affected. Some elephant groups may have been observed and recorded twice, and thus are not necessarily separate data. However, this could not be corrected for due to the difficulties in identifying individual elephants in such a brief period of data collection. In future studies, it would be worth the attempt to record interaction types between young and adolescence of different genders. Though this was an

area of interest, due to time limitations and visibility constraints, gender of elephants other than adults could not be determined with sufficient accuracy.

The importance of continued research in this field is imperative, as elephants are a keystone species and have a profound affect on their environment. They are valuable components of grazing succession, consuming tall grasses and significantly reducing plant mass, thereby allowing smaller ungulates to access food resources. Thus, reductions in elephant populations will have an indirect affect on the populations of many grazers lower on the grazing succession chain. Their feeding habitats are rather destructive, sometimes uprooting entire trees just to collect a few leaves (Dorst, 1970). In this way elephants effectively stop the regression of grasslands and provide grazers with important food resources. However, such habits can cause deforestation when carrying capacity of an ecosystem is surpassed, which recently has become a greater problem as more and more elephants are confined to the limited spaces of National Parks and Game Reserves. In this highly social species, sociality has a strong impact on fitness, and the confinement of elephants inside parks and games reserves will have strong consequences on social interactions as well as ability to maintain maximum population densities (Wittemyer and Getz 2007).- Because of the complexity of elephant social dynamics, studies examining complex social variables such as these are necessary to understanding how to protect them best in the future. Only then can predictions be made on how further changes will affect elephant populations, and thus the ecosystems in which they provide a vital role.

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Interaction	Adult Cow	Adolescent	Young
Cow	46.2%	58.9%	80.2%
Bull	1.5%	0.7%	0.1%
Adolescent	19.6%	16.4%	9.3%
Young	32.6%	24.0%	10.4%
Total	24.9%	20.7%	54.4%

Table 1. Percentage of interactions between varying age classes. Total shows the percentage of interactions exhibited by adult cow, adolescent, and young overall. All interactions with bulls were with an individualoutside the group.

	Adult Cow	Adolescent	Young	Bull
Affiliative	69.0%	82.3%	95.7%	32.1%
Aggressive	26.1%	13.8%	3.8%	49.1%
Submissive	4.8%	3.9%	0.5%	14.8%
Sexual	0.0%	0.0%	0.0%	4.1%

Table 2. Percentage of affiliative, aggressive and submissive behaviors shown by varying age classes.

Group size	Affiliative	Aggressive	Submissive
2-5	92.8%	5.4%	1.8%
6-10	87.9%	9.9%	2.1%
11-15	87.7%	9.7%	2.6%
>16	87.4%	11.5%	1.0%

Table 3. Mean percentage of affiliative, aggressive and submissive behaviors shown within varying sizes of matriarchal groups.
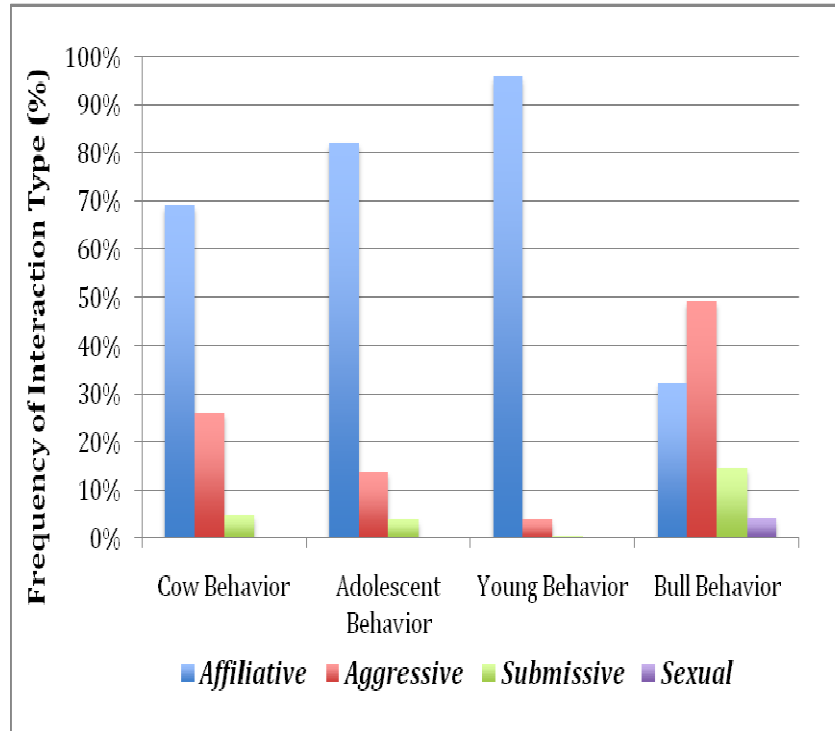
Figure 1. Interaction by Age Class: Mean percentage of interaction type by age class. Sexual interactions were observed only between adult bulls.
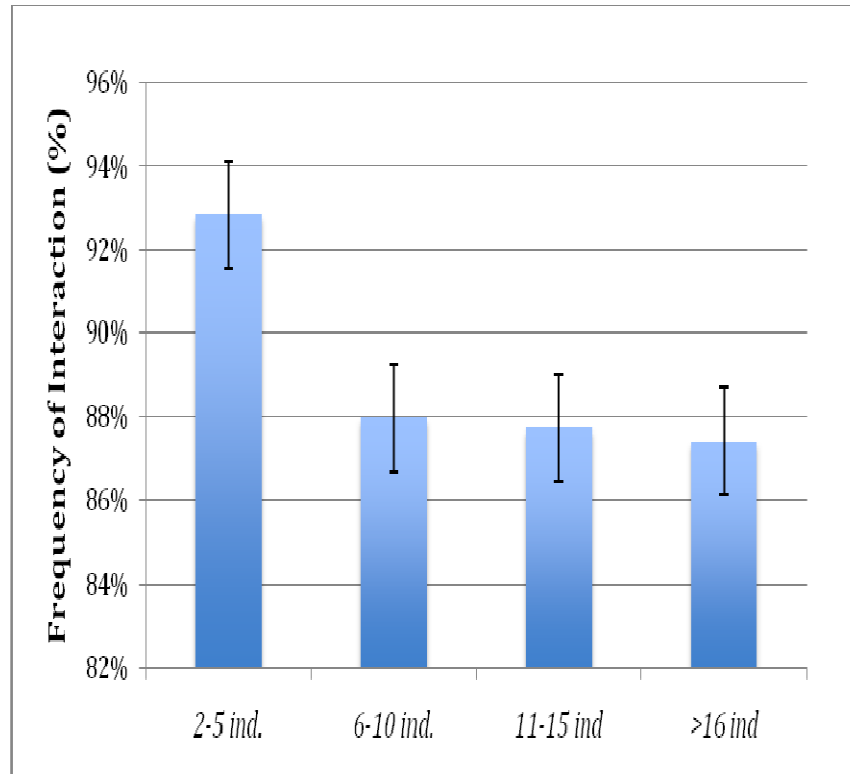
Figure 2. Affiliative Interactions: Mean percentage of affiliative interactions within varying group sizes. Error bars show 1.29% confidence intervals and indicate significance.
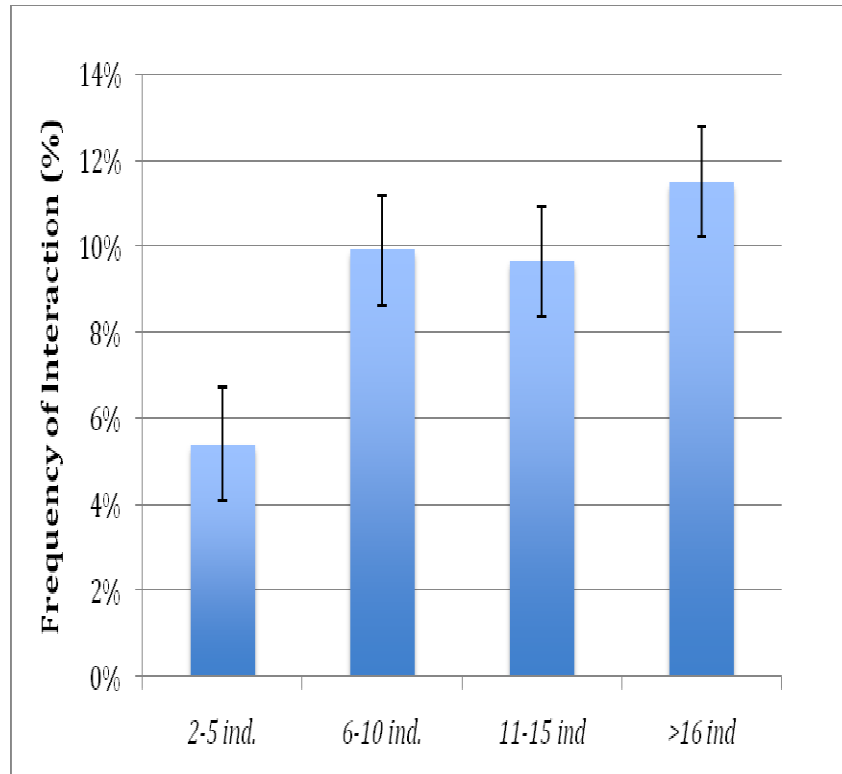
Figure 3. Aggressive Interactions: Mean percentage of aggressive interactions within varying group sizes. Error bars show 1.31% confidence intervals and indicate significance.
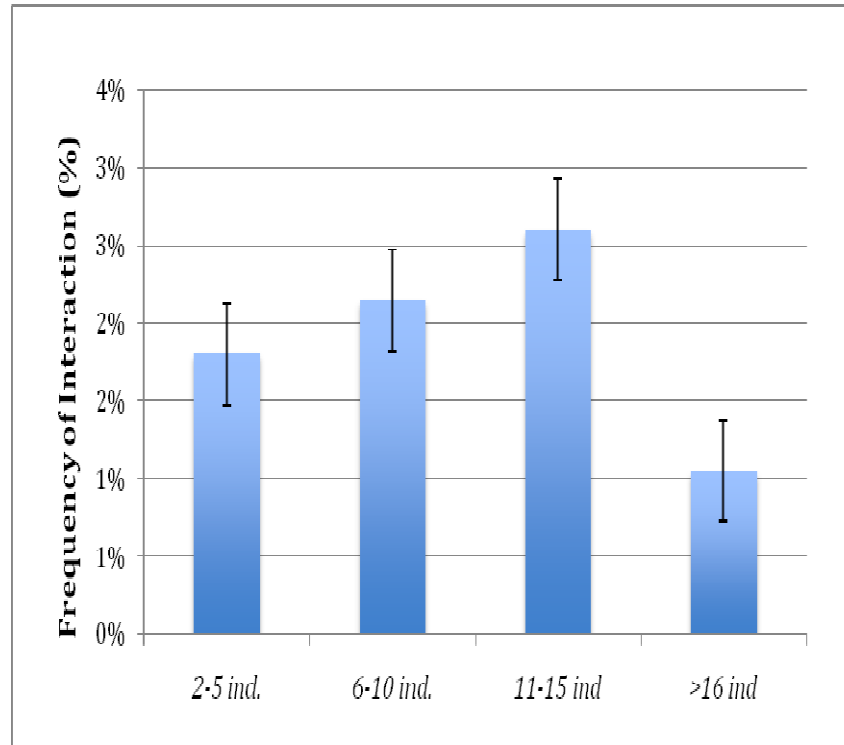
Figure 4. Submissive Interactions: Mean percentage of submissive interactions within varying group sizes. Error bars show 0.33% confidence intervals and indicate significance.

	African Elephant (*Loxodonta africana*) Ethogram	
	Focus on Interactive Behaviors	
Behavior Name	*Behavior Description*	*Code*
Affiliative Behavior:		
Approach	Move w/in 1 meter of another individual	app 1m
Trunk Greeting	Reach trunk toward another individual	TrGr
Trunk to Mouth	Trunk placed in other's mouth, (lower rank to elder)	TrGrM
Trunk Salute	Reach trunk toward another, place trunk in own mouth	Trsal
Trunk Contact	Trunk contacts another anywhere besides trunk or mouth	TrCon
Trunk Entwine	Two elephant trunks touch, often entwining together	TrEn
Trunk to tail	Trunk grabs another's tail, (often b/w mother and infant)	Trtail
Body Contact	Leaning against, rubbing, pressing back into another	Bcon
Follow	Follow w/in 5 meters, closely match pace	Fol
Walk Parallel	Walking side by side for at least 5 steps	WP

Aggressive Behavior:		
Standing Display	Aggressive stance facing another (head high, ears wide or flapping, swaying or leaning toward target)	Stdis
Saunter Display	Dominance display while walking (head bob up and down or side to side, ears wide or flapping)	Sd
Trunk Swing	Swinging or whipping the trunk about violently	Trsw
Trunk Slap	Trunk swing and hit recipient	Trsl
Head Agitation	Head nodding, Head shaking, or Head tossing	Hag
Mock Charge	Move toward w/ head high (slow or quick steps)	MCh
Charge	Charge towards or chase another elephant	Ch
Displacement	Approach another, recipient moves away w/in 10 sec	Dis
Nudge	Nudge w/ head or shoulders, or jab w/ tusks	N
Size Up	Face each other, heads raised and trunks entwine, ears wide, standing as tall as possible	SU
Wrestle	Tusks, trunks or heads push the other, continued grapple	Wr
Submissive Behavior:		
Retreat	Move away from another w/in 10 seconds of approach (backing up or turning to the side)	R
Sexual Behavior:		
Sexual Contact	Stand directly behind recipient, Trunk + Head resting on back, caress genitals w/ trunk	Sex-Con
Mount	Weight on hind legs, forelegs resting on recipient's hips	Mount

Main Sources: Compilation of my own observations, and behavior classifications cited in *The Behavior Guide to African Mammals by Estes*, and *Behavioral Responses of African Elephants, Loxodonta africana*, to tourist tucks in Tarangire National Park, by ACM student O'Neil.