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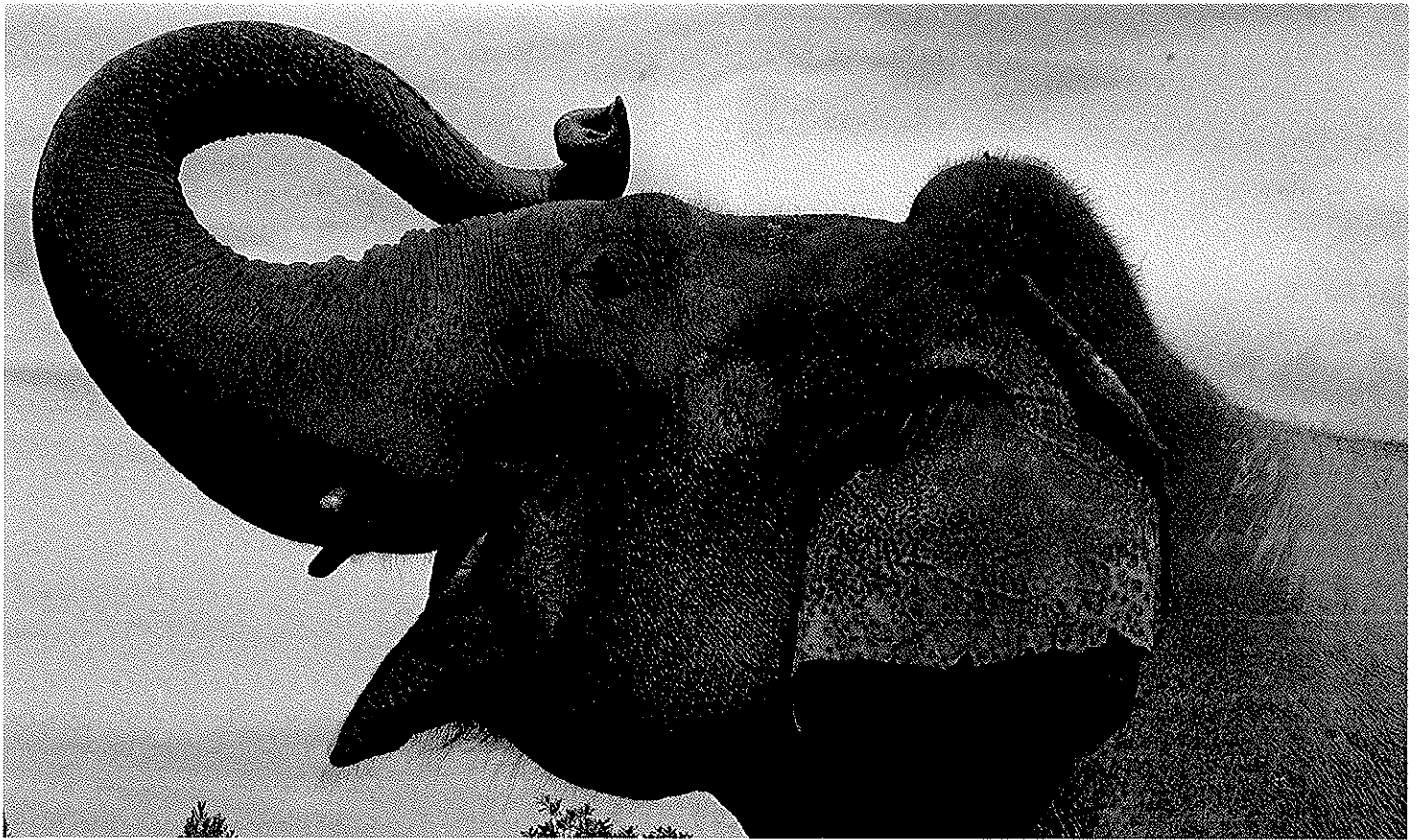
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A better understanding of musth as it occurs in captivity will help to make more informed management decisions and to enhance elephant welfare. Photo courtesy of Jessica Scallan Fidler.

A SURVEY OF MUSTH AMONG CAPTIVE MALE ELEPHANTS IN NORTH AMERICA: Updated Results and Implications for Management

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Introduction

Musth is a behavioral and physiological phenomenon that is unique to elephants, and in the wild, it serves as a multi-modal means of communication that allows a male elephant to announce his reproductive intent to both females and other males via temporal gland secretions and urine dribbling [Jainudeen *et al.*, 1972; Kahl and Armstrong, 2002; Poole 1987, 1989a, 1989b; Rasmussen *et al.*, 1996]. From a biological perspective, musth evolved in natural populations as a reproductive strategy that serves to increase the likelihood of receptivity by females, and it is present in both extant genera (*Elephas* and *Loxodonta*). Musth is closely correlated with heightened levels of serum testosterone, but except for the notable hormonal change, not all adult male elephants display the same symptoms during their musth cycles. For instance in competitive circumstances, musth signals a sort of dominance hierarchy among males with older, larger males advertising longer musth episodes with more obvious signals and younger males exhibiting less conspicuous musth-like symptoms (a state often termed 'moda musth') [Poole, 1989a; Rasmussen *et al.*, 2002]. The function and occurrence of musth as it occurs in captive populations is not fully understood and, as such, deserves further investigation.

Although musth is not physiologically necessary for reproduction—non-musth males can produce viable sperm—there appears to be an evolved social purpose for musth that should not necessarily be ignored in captive individuals [Howard et al., 1984; Thongtip *et al.*, 2008]. Aside from breeding concerns, we must also consider behavioral and welfare requirements when managing populations in captivity. In creating self-sustaining populations, we are not only preserving the genetic structure of each species but also the unique behavioral diversity that defines a species. Adult male elephants require special consideration in this regard because of their unique behavioral and social characteristics that strongly influence management practices. Additionally, with increased breeding success in the future it is likely that more institutions must be able to house adult male elephants, and this will require an elevated understanding of male elephant husbandry and management.

To the authors' knowledge, Scott and Riddle [2003] were the first to publish a study that emphasized the need to understand musth as it occurs in entire captive populations. The study, published in a previous issue of *JEMA*, was quite robust and included 48% of African (*L. africana*) and 86% of Asian (*E. maximus*) male elephants in the North American studbook populations at the time. They emphasized the serious need for an enhanced understanding of musth to maintain a self-sustaining captive population, but this topic is rarely addressed when implementing management practices. Furthermore, they found that musth in captivity varies significantly from what has been observed in the field - a large proportion of adult males experienced musth more than once per year (purportedly in sync with females in estrus). Additionally, even though the frequency or intensity of musth cycles experienced by wild elephants appears to be related to a male's age, Scott and Riddle found no correlation between the number of musth episodes experienced in a year and the current age of the male elephant as was observed in wild elephants [Poole, 1989a]. From this, it is clear that further study is warranted to better interpret musth in captivity, as environmental factors and individual differences are apparently quite strong in determining musth characteristics such as frequency, duration, and intensity.

The principal purpose of the current study was to update the findings of Scott and Riddle's original survey. We expected to observe considerable variation in musth with unclear environmental determinants that affect the frequency, duration, and intensity of musth episodes. We hypothesized that some of these environmental factors would include the presence of other males (and any age differences), access to conspecifics, and husbandry practices.



Musth is highly variable in captivity in terms of duration, frequency, and intensity. This likely requires individual attention to optimize daily and long-term management. Photo courtesy of Chase LaDue.

Methods

All data used in this study were acquired via an online survey in order to obtain information from as many elephant institutions possible, and responses were followed with personal interviews in certain cases when additional details or clarification were needed. The purpose of the present survey was two-fold: (1) to assess the readiness of North American elephant facilities to accommodate adult males in musth, and (2) to develop a greater understanding of the variation currently observed in captive musth cycles. As such, the survey was separated into two distinct parts: one to be completed once per institution (regardless of their male holding status) and the other to be completed for each adult male elephant at an institution. For our purposes, an adult male elephant was defined as one that had experienced a complete musth cycle at least once. This excluded some of the younger males who had gone through 'moda musth' but not full musth.

Data were collected from February through June 2013 from 57 different North American facilities that were holding African and Asian elephants at the time of collection (18

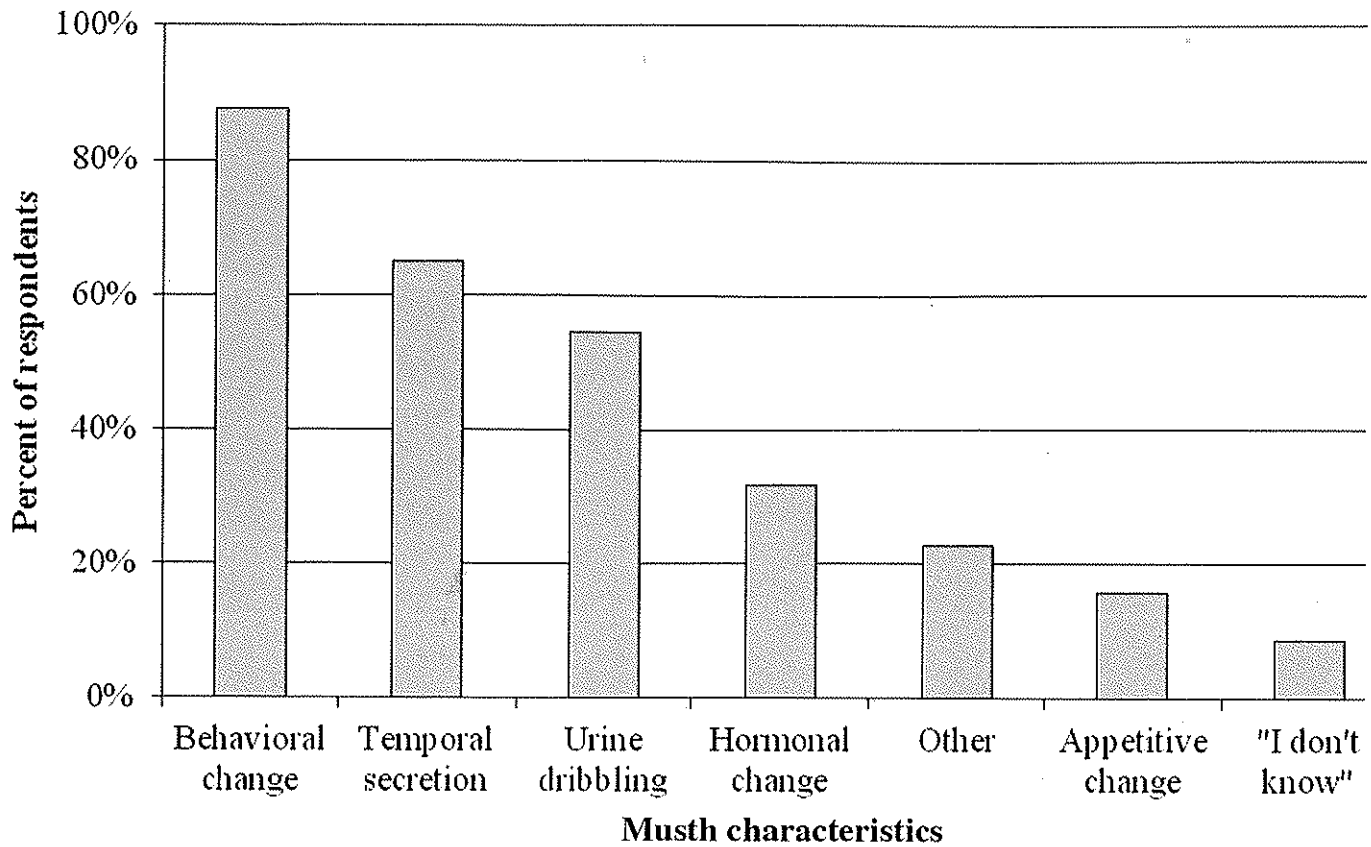


Figure 1: Responses to question: “In general terms, what criteria do you personally use to describe musth as it occurs in all male elephants?” Characteristic “I don’t know” indicates that the respondent could not provide a definition of musth. The respondents were unprompted (and therefore unaware of any criteria used to define musth used in subsequent questions) and musth characteristics were not mutually exclusive. n = 57.

of which held 21 adult male elephants), but seventy-four institutions were solicited to participate. Of these males, 20 were intact and had gone through a full musth cycle (one male had only experienced ‘moda musth’), and of these elephants, 12 were Asian (*E. maximus*) and 8 were African (*L. africana*). A link to the brief online survey was e-mailed to experienced zoo personnel (including curators, elephant managers, and elephant keepers) and was designed so that there was opportunity to comment on a specific male’s musth episodes if more detail was needed.

Part One of the survey focused on the present male holding status at each institution, any future plans to modify facilities in order to accommodate adult male elephants, and any reasons that an institution could not currently house adult male elephants. Before completing the second part of the survey, respondents were asked to describe musth as it applies to all adult male elephants in an attempt to gauge current knowledge of musth among elephant professionals and to account for any bias between institutions that may be reflected in future questions. It is important to note that this aspect of the survey was not included in the original study conducted by Scott and Riddle.

The second part of the survey included questions regarding the characteristics and timing of a male’s first musth episode (when available), the traits (e.g., temporal gland secretions, changes in serum testosterone, urine dribbling, and behavioral changes), frequency/duration of current musth cycles, any husbandry practices used by a facility to better cope with a male’s musth, and any social contact with conspecifics that a male has during and between musth cycles. The questions included Part Two of the survey mirrored the questions that were originally asked of respondents by Scott and Riddle in their 2003 study.

Results

Of the fifty-seven institutions surveyed, 63% were physically capable of holding adult male elephants (disregarding space limitations). Nine additional respondents indicated that his or her institution was planning on modifying their facilities to accommodate adult male elephants within fifteen years. Of those institutions that could physically hold males, only 51% currently held males at the time data were collected. Of the thirteen institutions that were physically capable of housing male elephants yet only housed females, three specified that space limitations prevented them from

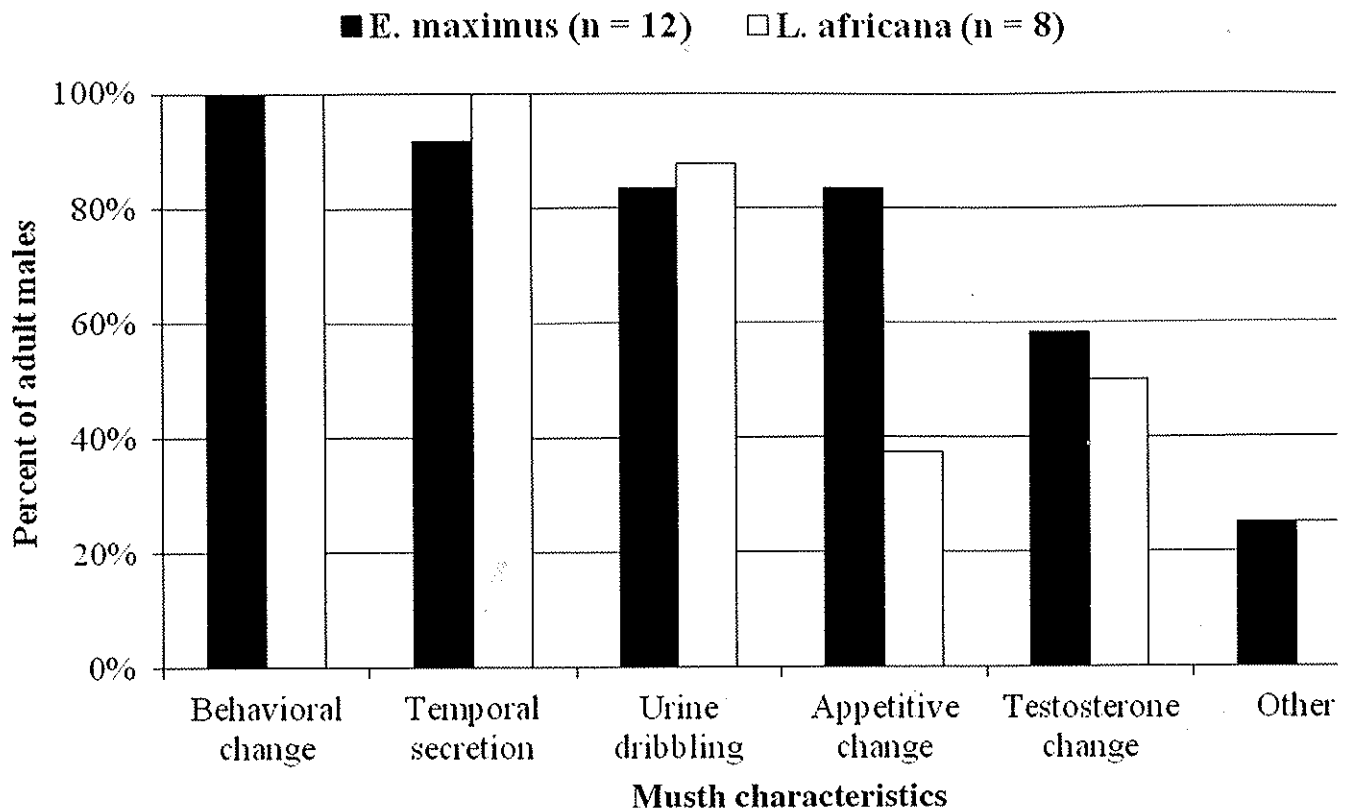


Figure 2: Responses regarding the characteristics of surveyed males' musth cycles (n = 20). These choices of musth characteristics were offered to respondents for specific classification. The characteristics were not mutually exclusive.

doing so, seven indicated that they were recommended against holding males for breeding purposes from AZA's elephant SSPs, and eight listed other specific reasons for their current herd status (these categories were not mutually exclusive).

Respondents were also asked during the first part of the survey to define musth in general terms—not necessarily with respect to specific males at their institutions. It is important to note that these responses were unprompted, so the results reflect the knowledge of the respondents before reading any questions that investigated details of musth in captivity. The most frequently referenced term provided by the respondents was behavioral change (n = 50) while the least common characteristic was appetitive change (changes in regular feeding or drinking regimens; n = 9) (Figure 1). Interestingly, five respondents indicated that they could not provide any sort of definition for a generalized musth cycle. The respondents whose institutions held adult male elephants at the time of the survey were asked to describe the characteristics of their individual males' musth cycles (n = 20). These results are illustrated by species in Figure 2. Nineteen out of twenty males exhibited both temporal gland secretions and behavioral changes during

musth. Only eleven males were known to show serum testosterone changes during musth. Respondents that indicated their males exhibited characteristics not included in the survey provided characteristics such as green penis syndrome and changes in attitude or demeanor among their males during musth. The most frequently cited behavioral changes among males were aggression (89% of males), uncooperativeness (61%), a detached/spacey demeanor (44%), and a greater interest in female conspecifics (44%). There were no substantial differences in musth characteristics between species aside from appetitive change. (Asian elephants more frequently went through appetitive changes during musth than African elephants which was the opposite result of what was described in Scott and Riddle's original musth survey [2003]). Respondents were also asked how long their males experienced musth during a typical episode, and also how frequently their males went through musth in an average year. These results are shown in Figure 3 and Figure 4. On average, Asian elephants experienced musth for shorter duration (about 46 days) than African elephants (about 86 days). However, both Asian and African elephants exhibited musth with approximately equal frequency (about 1.34 and 1.46

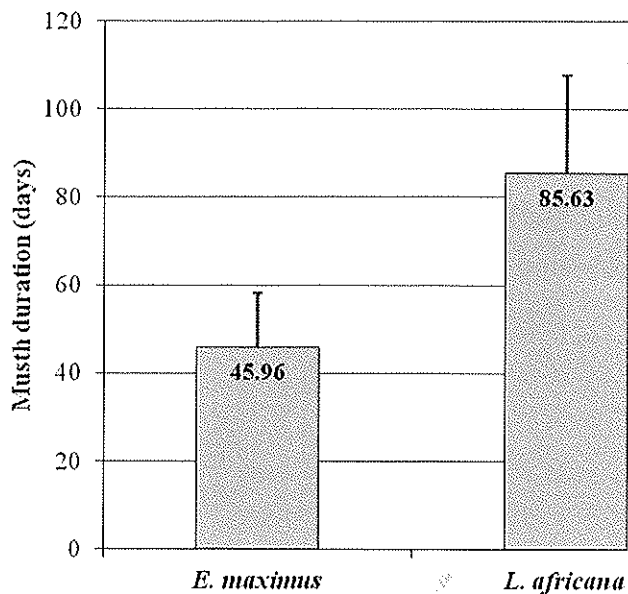


Figure 3: Mean duration of musth episodes for Asian (*E. maximus*) and African (*L. africana*) elephants. Error bars show calculated standard errors of the mean.

times per year, respectively). Additionally, age was not a reliable predictor for either duration or frequency of musth for either species.

Discussion

In terms of the readiness of North American institutions to accommodate adult male elephants, it appears that there is more available physical space for males than is often reported. Only three of the facilities that were physically capable of housing adult males (but did not do so at the time of the survey) indicated that space was a limitation in terms of their ability to hold males. Moreover, some facilities stated that the lack of available males limited their institution from holding adult males. This reflects a problem faced by many unsustainable captive populations - an overall lack of breeding individuals to exchange between institutions.

There is also great variation in the knowledge of musth among survey respondents. This may suggest that keepers, managers, and other elephant professionals could benefit from further training regarding musth, especially as it occurs in captivity. For instance, only 31% of respondents described testosterone changes in their definitions of musth even though it has been shown that these changes may be the largest determinants of musth in the wild and in captivity [Jainudeen et al., 1972; Rasmussen *et al.*, 1996]. This may have been due to the fact that some institutions may not regularly measure serum testosterone levels, and, therefore, these changes would go unnoticed. Behavioral changes are often the most evident indicators of musth when compared

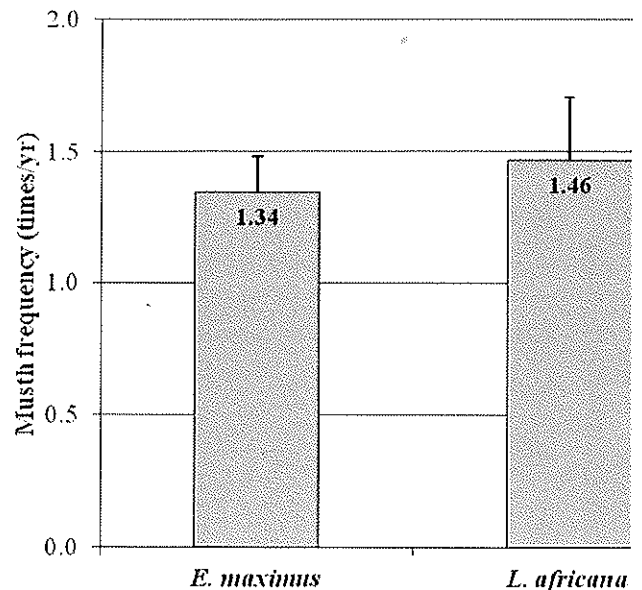


Figure 4: Mean frequency of musth episodes for Asian (*E. maximus*) and African (*L. africana*) elephants. Error bars show calculated standard errors of the mean.

to other characteristics, and it is not surprising that most professionals use behavior to characterize musth. Nonetheless, certainly broader, more standardized training is conducive to a more educated population of future elephant professionals that is more capable of handling captive sustainability issues.

A high proportion of surveyed males exhibited changes in behavior, temporal gland secretions, and urine dribbling during their musth cycles. As expected, there was no discernible relationship between the musth characteristics exhibited by a male and his age, species, or social condition (minor differences between species were likely due to the small sample size). This further clarifies the need to address each captive male on an individual basis because, to our best knowledge, it is evident that there is no reliable predictor that can be ascertained from the suite of environmental conditions. If keepers are better able to identify when a male is reaching the onset of musth through the observation of known traits, they will be better prepared to care for and manage that male in future musth cycles. Developing methods to monitor testosterone levels through non-invasive means also increases the likelihood that musth can be detected before it actually occurs. Further characterizing each male's testosterone cyclicity may lead to the use of hormone standards as predictive gauges to enhance management and breeding efforts.

Scott and Riddle [2003] reported similar characteristics among captive males in musth with 85% to 95% of surveyed males regularly experiencing temporal gland secretions

Table 1: Comparison of adult males that were included in this survey as well as Scott and Riddle's original 2003 survey. Age, duration, and frequency are indicated in 2003 and 2013. There is no clear pattern in the development of a male's musth cycle as he ages, and, therefore, musth is likely subject to individual differences.

Individual	Species	Age in years (2003 / 2013)	Musth duration in days (2003 / 2013)	Musth episodes per year (2003 / 2013)
1	Asian	41 / 51	67.5 / 14	2 / 1
2	Asian	31 / 41	45 / 5.5	2.5 / 1.6
3	Asian	25 / 35	17.5 / 37	1 / 1.3
4	African	29 / 39	45 / 165	2.5 / 1.6
5	African	24 / 34	0 / 90	0 / 3

and behavioral changes during their musth episodes. As in this study, they were also unable to correlate traits such as musth frequency or duration to a male's age, species, or access to male or female conspecifics. There are a number of environmental and individual factors that can potentially influence musth's observable characteristics, and only through careful analysis on an individual level will we more fully understand such relationships. To further illustrate the degree of variation in musth within individuals as they age, data from five males included in both surveys are shown in Table 1. With age, all males experienced changes in the duration and frequency of musth. As was described by Scott and Riddle [2003], a large proportion of captive males seem to synchronize their musth cycles with female estrus in an apparent attempt to maximize the likelihood of conception. This process certainly needs more investigation, as the data indicate that increased breeding success may be dependent on a more careful consideration of social factors. Musth's occurrence in captivity can be effectively utilized to address sustainability issues. It is also unclear why only certain males appear to exhibit musth in synchrony with female estrus, and, furthermore, with only particular females at a given institution. Communication is integral in such social species, and communicative means that are not easily detected by humans (such as auditory and chemical cues) are known to exist in elephants.

From knowledge gained in this study, musth as it occurs in captivity appears to differ substantially from musth in the wild in that there is great variation observed among adult males. More intensive behavioral and physiological studies in the future will likely lend more insight into the idiosyncrasies of captive male elephant reproduction. It is also beneficial for all elephant institutions—even those not housing breeding male elephants—to understand the role of musth in elephant social behavior and reproduction and how we can better manage males in musth to create and maintain sustainable captive populations.

Conclusions

1. More North American institutions will be able to accommodate adult male elephants in the future, and, therefore, a greater understanding of musth as it occurs in captivity is likely necessary. From unprompted survey responses, it is also clear that there is a wide range in experience with musth among elephant professionals.

2. In corroboration with Scott and Riddle's original 2003 study, there appears to be differences in key characteristics (such as duration and frequency) between musth as it is exhibited in the wild and captivity. Unlike the conclusions gathered from field studies, our data indicate that age is not a reliable indicator of musth duration, frequency, or intensity.

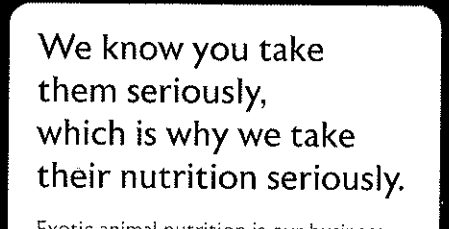
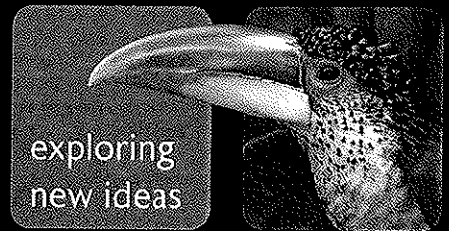
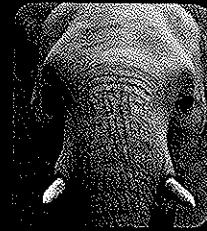
3. Captivity appears to strongly influence a male's musth cycles which may be attributed to increased access to male and female conspecifics, optimal diet availability, and limited space. Further investigation that isolate the effects of husbandry practices and housing conditions will likely explain the observed differences in captive musth cycles.

Acknowledgements

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