



**MUSTH VARIATION AMONG ASIAN ELEPHANTS (*ELEPHAS MAXIMUS*):
APPLICATIONS FOR CONSERVATION**

Interim Report prepared for the International Elephant Foundation

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2) OVERALL AND SPECIFIC CONSERVATION NEEDS

- Asian elephants (*Elephas maximus*) are endangered and threatened by human–elephant conflict (HEC). HEC in Sri Lanka is prevalent, with approximately 100 humans and 360 elephants dying from HEC in 2019. Male elephants in musth are implicated in HEC at disproportionately high rates. Understanding musth in Asian elephants is critical for management and will help to address the root causes of HEC.
- With enhanced breeding success, more *ex-situ* elephant facilities will hold males, and many will likely house multiple males. Successful management strategies should carefully consider musth, but that requires a greater understanding of social and environmental factors that shape it.
- We still do not know how or in what way social interactions and other environmental pressures shape the characteristics and patterns of musth on the individual, population, and species levels in Asian elephants. Without this information, we cannot ensure that management strategies for *in-situ* and *ex-situ* elephant populations are most effectively advancing individual well-being and reproduction.
- Our comprehensive study of musth, combining direct behavioral observations and physiological assessments, will be the first to investigate this phenomenon simultaneously in captive and wild Asian elephant populations.

3) GOALS AND OBJECTIVES

A systematic investigation of musth in Asian elephant populations is urgently needed to inform *in-situ* and *ex-situ* management strategies. We have not changed our original goal or objectives (we have added one objective, see below). Our goal is to gather behavioral, physiological, and acoustic data about male Asian elephants in musth, with recognition of the influence of intrinsic (age, condition) and extrinsic (social, environmental) factors. Specifically, we seek to achieve the following objectives:

1. Our first objective is to quantify the behavioral correlates of Asian elephant musth in field and captive conditions. Behaviors such as agonism, social behavior, investigatory behavior, stereotypy, locomotion, and feeding are recorded as well as environmental conditions and characteristics musth symptoms exhibited by the focal male. We will be comparing duration and frequency of behaviors between musth and non-musth, as well as *in-situ* and *ex-situ* males using generalized linear mixed effect models that integrate intrinsic, social, and environmental predictors.
2. Our second objective is to quantify sexual (i.e., testosterone) and metabolic (i.e., thyroid and cortisol) hormone variation among male Asian elephants in and out of musth, and then correlate these values with environmental factors. We will measure testosterone, thyroid hormone, and cortisol metabolites non-invasively in feces to compare the concentrations of these hormones in male elephants across a range of intrinsic (age, body condition, musth status) and extrinsic (social access, habitat type, climate) variables. Coupling these metabolite measurements with behavioral analyses will lead to a more accurate explanation of how male Asian elephant behavior and physiology varies during musth.
3. Our third objective is to identify unique acoustic components to the musth signal. To accomplish this, we measure the vocalizations of identified males in and out of musth, and then compare them by measuring differences in temporal and structural characteristics.
4. We have added one new objective to our project: quantify and analyze the patterns of scar on elephants of various demographics at our study sites in Sri Lanka. Unexpectedly, we found

that the easiest way to distinguish elephants in the field from each other was through scar patterns across their bodies. Because very few elephants in Sri Lanka have tusks (estimated <5% of males), and there isn't vegetation with heavy thorns, we assume the vast majority of these scars are incurred during crop-raiding incidents or other forms of HEC. At Wasgamuwa, we found that these scars were much more common on older male elephants, which supports other studies that found that these elephants are the most frequent crop-raiders. During our second field season, we hope to find similar patterns occur in Kaudulla and Minneriya National Parks. Because photographs can be taken in conjunction with the existing fieldwork (with no extra opportunity or monetary cost), this objective will not detract from those already described to IEF.

4) SPECIFIC ACTIONS TAKEN

The objectives listed above all occur simultaneously, so the following description applies to all of our proposed objectives.

In-situ component:

Co-PI LaDue arrived in Sri Lanka in November 2018, and soon after his arrival, he obtained a resident visa to secure research permits from the Department of Wildlife Conservation with the help of co-investigator Vandercone. We began data collection in December 2018 at Wasgamuwa National Park after securing housing, transportation, and a field assistant (Sachintha Samaraweera). We started at Wasgamuwa because elephants were located in and around the North Central Province during the rainy season. We successfully liaised with park officials, wardens, rangers, and trackers at Wasgamuwa to facilitate data collection. It is a requirement to have a member of park staff in our vehicle at all times.

In Wasgamuwa, we conducted over 300 hours of field effort, which yielded 1,988 elephant sightings (males and females) in 382 separate events. We successfully identified 71 adult male elephants based upon physical attributes, which includes photographing each elephant to make identification cards that were later bound into a physical guide. These cards were useful to have with us in the vehicle at all times to aid in field identification, and we donated six complete identification guides to Wasgamuwa National Park. We found that these guides encourage trackers to engage more with the wildlife they are seeing. We conducted 209 behavioral observation and acoustic recording sessions and collected 37 fecal samples.

During non-fieldwork days in Sri Lanka, we organized and processed behavioral and acoustic data, and we began the extraction process for the fecal samples. Before fecal samples can be analyzed for hormone metabolites, they must be dried, pulverized, precisely weighed, and extracted in a methanol solution. This process can take up to a week per sample, and samples were run in batches of 15 samples to maximize efficiency.

As we prepare to resume fieldwork in Sri Lanka in May 2020, we have already begun preparation to return to the island. We will renew our research permits in March and April 2020.

Ex-situ component:

We began data collection at US zoos in July 2018 before co-PI LaDue left for Sri Lanka. During the summer, co-PI LaDue visited five elephant facilities (Smithsonian's National Zoo, Ringling Bros. Center for Elephant Conservation, Houston Zoo, Fort Worth Zoo, and Oklahoma City Zoo) to observe and record elephants and collect fecal samples. These efforts continued in June 2019.

We visited four more facilities (Rosamond Gifford Zoo, Denver Zoo, Cincinnati Zoo and Botanical Gardens, and Columbus Zoo and Aquarium) and returned to Fort Worth Zoo for more observations in summer 2019. In fall and winter 2020, we visited Saint Louis Zoo, Denver Zoo, and Fort Worth Zoo.

We also coordinated with participating elephant facilities to begin weekly fecal collections from each of their bulls starting in July 2019 and lasting through August 2020. Along with these weekly samples, each facility will record weekly information about musth status (temporal gland secretions and urine dribbling), body condition, and social access using a musth scoring chart we created (shown on right).

Since *ex-situ* data collection began, we have collected over 300 hours of behavioral data and over 900 fecal samples. With the help of undergraduate and post-graduate research students from George Mason University, we have processed almost half of these samples already (with the processing phase ongoing) so that we can begin lab analyses shortly after data collection in Sri Lanka ends.

5) CHANGES IN ACTIVITIES

No major changes in our originally proposed activities have occurred.

6) CONSERVATION OUTCOMES

As this is an ongoing research project, the current applications and outcomes for conservation directly emanating from this work is limited. However, we have made specific efforts to engage with local and global communities during the course of our work. We have an online presence via Twitter (@ChaseLaDue), Instagram (#projectmusth), and a blog (www.cladue.org/blog). These efforts are aligned with IEF's social media presence with overlapping content. We contributed musth-related photos and facts for IEF's weekly Elefun Fact Friday. We also shared preliminary results from our project at the 16th International Elephant Conservation and Research Symposium in October 2019 and at the Virginia Chapter of The Wildlife Society in February 2020.

Locally, we engaged with Sri Lankan university students through informal and formal lectures, and built capacity by hiring a postgraduate student to aid in data collection and other fieldwork efforts. We created elephant identification guides for Wasgamuwa National Park, which were distributed to park staff.

7) PROJECT IMPACT

Our project is ongoing and the specific applications of the results are yet to come, so it is difficult to quantify the impact of our work on human communities. One of our widest reaching impacts so far is our online blog detailing the fieldwork in Sri Lanka (www.cladue.org/blog). Since the start of the project in November 2018, the blog has been visited by over 1,500 unique people in 49 different countries.

In Sri Lanka at Wasgamuwa National Park, we have had 1,988 total elephant sightings from 382 separate events. We have identified 71 individual adult bull elephants during fieldwork (46 of these have been observed multiple times). Our ID guides can be used to definitively identify these male elephants. A few of these guides were given to a community leader in the hopes that crop-raiding male elephants in the area can be identified in the future, possibly pointing to repetitive crop-raiders.

In the US, we are working with 10 elephant facilities that house 26 adult bulls, approximately 65% of the North American Asian elephant population.

8) PROBLEMS DURING GRANT PERIOD

No major problems have been encountered since the last interim report.

9) PROJECT EVALUATION

So far, despite the logistical challenges we have faced, we believe our project has been progressing successfully. We will resume fieldwork in Sri Lanka in May 2020 for data collection in Kaudulla and Minneriya National Parks, we are on track to complete the objectives described in our original proposal (along with the additional objective we added, described in a previous section). In Sri Lanka, we will continue building our bull elephant identification database, conducting behavioral and acoustic observation sessions, and collecting fecal samples for hormone analysis. After we finish collecting data in Sri Lanka, we will begin analyzing our data to better understand how musth varies with the range of environmental and social conditions experienced by bull elephants. In the long term, we will continue maintaining our relationships with Department of Wildlife Conservation officials in Sri Lanka so that our results can be used in developing more effective elephant management strategies.

Similarly, the *ex-situ* component of the project is moving along as planned, albeit on a different timeline than we originally proposed. We continue to be in close contact with all of our participating elephant facilities, while conducting site visits whenever possible.

10) NEXT STEPS

We will resume fieldwork in Sri Lanka in May 2020, finishing at Kaudulla and Minneriya National Parks in August 2020. Fecal samples will be shipped back to the US in August for laboratory analyses. Summary reports for Sri Lankan wildlife officials will be prepared and presented before the project's end in Sri Lanka.

Data collection at zoos across the US will be completed by the end of 2020. We have begun training research students here in the US to continue the project while co-PI LaDue is in Sri Lanka over the summer. While not originally part of the plan, we are confident that the *in-situ* and *ex-situ* components of the project can happen simultaneously with our diligent planning.

11) HUMAN INTEREST STORIES

In our last report, we shared stories of Sri Lankans who contributed to our project in unexpected ways. We are passionate about these stories, because it is ultimately people that live among elephants who will determine their survival. As such, we plan to continue involving Sri Lankans in our research when data collection resumes in May 2020, and we will share stories of their engagement in our next report.

Since *ex-situ* data collection began, we have also involved students in our project, albeit those that live in the US. We are proud to be training students from traditionally underrepresented groups who have a variety of scientific career goals, including industry laboratory work, veterinary medicine, and scientific research (e.g., graduate school).

12) PROGRESS SUMMARY

We are currently undertaking a research project to better understand the environmental and social correlates of musth in Asian elephants in Sri Lanka (*in-situ*), along with a complementary study of musth in captive Asian elephants in the US (*ex-situ*). To better understand the drivers of musth variation, we are using an integrative approach, measuring behavior, physiology (i.e., through hormones), and acoustic communication in *in-situ* and *ex-situ* male elephants in and out of musth. Currently, we are in the middle of data collection for both the wild and captive components of our project; data collection will be completed by the end of 2020. Data analysis will continue through 2021, and we will begin sharing our results through publications and presentations at professional meetings in mid-2021. Our results hold promise to inform effective elephant management strategies in Sri Lanka, the US, and beyond. The success of our project so far can also be measured in the impact to people it has had. We make a point to actively engage with community leaders in the places we work, providing them with elephant ID books so that they can identify elephants that approach their farms. We collaborate with Sri Lanka's Department of Wildlife Conservation, including the wardens, rangers, and trackers that work in the national parks. We have formal and informal conversations about elephants and the wildlife they share habitats with, providing trackers with wildlife identification manuals and our own elephant ID guides. Beyond Sri Lanka, our virtual presence in the form of an online blog has reached over 1,500 people in 49 countries, spreading the word about the importance of elephant conservation. With the help of IEF, we have been able to reach even more people through social media. And perhaps most rewarding, to build capacity in Sri Lanka and the US, we are training undergraduate students in non-invasive wildlife monitoring techniques.

13) ASSOCIATED ORGANIZATIONS

The investigators are associated with the following organizations: George Mason University School of Integrative Studies (EWF) and Department of Environmental Science and Policy (EWF and CAL); Feld Entertainment, Inc. Ringling Bros. Center for Elephant Conservation (WKK) and Ringling Bros. Center for the Study and Conservation of the Asian Elephant (WKK and RPV); and Rajarata University of Sri Lanka Faculty of Applied Sciences (RPV).

Besides IEF, the following organizations have provided funding for this project: American Society of Mammalogists; Animal Behavior Society; Asian Elephant Support; Cosmos Club Foundation; Elephant Managers Association; The Explorers Club; Feld Entertainment, Inc.; Fulbright US Student Program; George Mason University School of Integrative Studies, Office of the Provost, Department of Biology, and Smithsonian-Mason School of Conservation; IDEA WILD; National Geographic Society; Oklahoma City Zoo Conservation Action Now program; Saint Louis Zoo WildCare Institute; and Virginia Academy of Science.

14) ITEMIZED IEF FINANCIAL REPORT

Current as of March 1, 2020. All amounts are in USD.

	Amount requested from IEF	Amount spent	Amount remaining
4x4 rental with ranger in Sri Lanka	3,000	2,750	250
Endocrine equipment: pipettes, balances, tube shaker, freezer, wash bottles, test tube racks, etc.	2,500	0	2,500
Behavioral equipment: tablet and case, weather meter, binoculars, camcorder	156	156	0
Hormone (EIA) kits: testosterone, corticosterone, T3	3,564	0	3,564
Disposable lab supplies: fecal bags, test tubes, pipette tips, storage boxes, solvent, etc.	1,500	130	1,370
TOTAL	10,720	3,036	7,684

Most of the funds requested from IEF have been spent on costs related to fieldwork (i.e., travel and behavioral sampling equipment). Our original proposal included a timeline in which lab analyses would take place after *in-situ* sampling from August through December 2019. However, it is not appropriate to conduct these analyses until all fecal samples have been collected. Because our fieldwork has been postponed and will not be completed until August 2020, lab analyses will not be completed until December 2020. Most of the remaining IEF funds will be used to complete these analyses by purchasing lab supplies and hormone kits. Because these kits have a limited shelf life, they will be purchased closer to the end of 2020 when lab analyses begin. An extension for spending these funds was granted via email on June 10, 2019.

15) PHOTOGRAPHS

The following photographs are representative of our work thus far. The images are also included as separate attachments to this report.



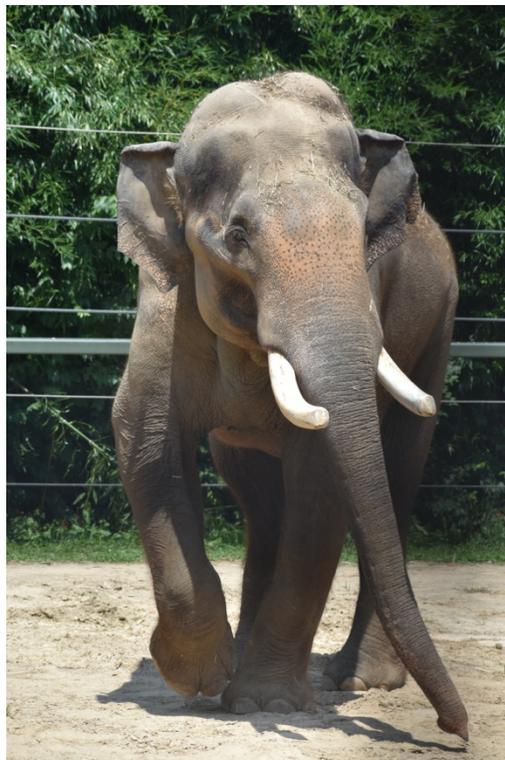
A male elephant in musth walks by a crowd of tourist vehicles in a national park in Sri Lanka. People from all over the world visit Sri Lanka to see elephants, making elephants an important part of Sri Lanka's economy. However, people that live around elephants often have a different view. Photo by Chase LaDue.



A large group of elephants congregates around a water tank in Minneriya National Park, Sri Lanka. During the right time of year, it is not uncommon to see these large aggregations in Minneriya daily. Photo by Chase LaDue.



Project team members collect a fecal sample from a bull elephant in Wasgamuwa National Park after he has moved a safe distance away. Photo by Wendy Kiso.



“Sabu” (Cincinnati Zoo & Botanical Garden, 32 years old) in musth. Photo by Chase LaDue.



At Columbus Zoo and Aquarium: “Beco” (left, 10 years old) and “Hank” (right, 32 years old) interacting with each other. We now know that socialization can be important and enriching for the healthy development of a male elephant. Photo by Chase LaDue.



“Raja” (Saint Louis Zoo, 27 years old) in musth. Photo by Chase LaDue.

16) VIDEO UPDATE

We have attached a video update to our report. The transcript is included below:

Hi, I'm Chase LaDue, and I'm a biologist and graduate student at George Mason University. I work on a project supported in part by the International Elephant Foundation, and together with a team of researchers including other biologists, conservationists, and field assistants, we study Asian elephants in Sri Lanka and other parts of the world.

Sri Lanka is known as the pearl of the Indian Ocean, and despite its small size, it hosts the largest concentration of elephants anywhere in Asia. The human population in Sri Lanka continues to grow, and with this growing human footprint, it is more common for humans and elephants to use the same resources and landscapes. This leads to frequent human–elephant conflict on the island, often in the form of elephants raiding nearby farms for crops. As large as they are, even a small group of elephants can wipe out a farmer's entire annual crop yield in a single night, threatening the livelihoods of many Sri Lankans. At the same time, this conflict can be dangerous for humans and elephants as farmers try to protect their land. We suspect that many of these conflict elephants are adult males that are motivated to feed on nutritious crops, especially during a period called musth.

Musth is a period of heightened reproduction that is unique to male elephants, and during musth, males send various signals to other elephants in the area that they are ready to mate. This phenomenon is triggered by a surge in testosterone, and so musth males can be especially aggressive towards people, making the problem of human–elephant conflict even worse. Our project seeks to better understand the flexibility of musth, including how male elephants interact with each other, other elephants, and the environment around them. If we can figure out how male elephants spend their time and change their behavior and physiology during musth across a range of different habitats, we can more effectively conserve Asian elephants by developing strategies that specifically target male elephants, who are most commonly involved in human–elephant conflict.

Our integrative research measures the behavioral, acoustic, and physiological components of musth, both among wild elephants in Sri Lanka and in elephants housed in facilities across the US. In sampling both of these populations through a field-to-fence approach, we hope to get a more all-encompassing idea of how flexible musth is. As zoos achieve greater success in breeding elephants and creating their own self-sustaining populations, it will also be important to understand how best to care for male elephants, especially during the time of musth.

Conserving elephants is critical. Elephants are keystone species, helping foster other animals and plants that they share habitats with. If we save elephants, we are also helping countless other species. Even beyond that, tourists come from all over the world to see elephants in Sri Lanka, meaning that elephants are important for Sri Lanka's continued economic prosperity. However, people who actually live among elephants can have a very different perspective. Ultimately, it will be up to communities like these throughout Africa and Asia that determine the future of elephants. We sincerely appreciate the work of organizations like the International Elephant Foundation that promote positive, sustainable ways to connect people and elephants, for the good of all of us and the planet we share.

If you would like to support our project and many others, please visit ElephantConservation.org. Thank you for caring and helping elephants everywhere.

17) PUBLICATIONS AND PRESENTATIONS

Since the last progress report, we presented some of this work at the 16th International Elephant Conservation and Research Symposium in South Africa in October 2019 and at the Virginia Chapter of The Wildlife Society in February 2020.

After data collection ends in December 2020, we anticipate presenting more data at meetings such as a future International Elephant Conservation and Research Symposium and other conferences (e.g., Elephant Managers Association, Animal Behavior Society, International Society for Wildlife Endocrinology, Association of Zoos and Aquariums). We also will be submitting manuscripts resulting from this project between December 2019 and May 2021. Journals of interest include *Gajah*, *Animal Behaviour*, *Zoo Biology*, *Conservation Physiology*, *Oryx*, *Biological Conservation*, and/or *General and Comparative Endocrinology*. We will share all resulting publications with IEF, and all publications and presentations will acknowledge IEF's support.

18) MEDIA COVERAGE

Since our last interim report, our project was featured by the Denver Zoo in August 2019: <https://www.denverzoo.org/zootales/if-you-musth-know/?fbclid=IwAR1PhKMjwQ59zQOAJkC9f0ZBzVOd4Kzg2DU5gU1SJ5Aq2S6M5zhj6RYuSQ4>

19) INTERNET COVERAGE

Co-PI LaDue has shared the progress of this project on his blog (www.cladue.org/blog) and his social media accounts (via Twitter [@ChaseLaDue](#) and via Instagram [@ele_chase](#) and [#projectmusth](#)).