● シャルマ ポカレル サンジータ 特定助教

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研 究 課 題： 絶滅した古代日本ゾウの古生態を再構築する
（Reconstructing paleoecology of extinct Japanese elephant species）
専 門 分 野： 野生動物内分泌学、保全生理学、哺乳類生態学、行動生態学、化学生態学（Wildlife Endocrinology, Conservation Physiology, Mammalian Ecology, Behavioral Ecology, Chemical Ecology）
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Spanning over a decade, my research evolved from understanding the physiological adaptive mechanisms of free-ranging Asian elephants in response to their rapidly changing environments. Studies show that elephants attempt to "adapt" to extreme challenges, physiologically and behaviorally. Therefore, the primary focus of my research is to investigate the long-term consequences of these short-term adaptations on the fitness and survivability of elephants. Recognizing the challenges of studying long-lived elephants over generations, I have sought to study elephants retrospectively. As a Hakubi researcher, I will undertake a retrospective study to delve into the past (paleoecology) of extinct elephants (proboscideans) to predict the future (fitness and survival consequences) of extant (living) elephants.
In the Anthropocene, animals must learn to adapt to climatic/anthropogenic challenges to support their survivability. It is crucial to examine whether slow-reproducing and long-living species, such as elephants, are physiologically fit enough to survive extreme disturbances. Recent research, including my own, suggests that elephants have remarkable adaptive mechanisms to cope with their changing surroundings; however, consequences on their fitness remain unexplored. Climatic effects, over generations, are furthermore challenging to assess. This research, therefore, aims to (i) retrospectively investigate how extinct Japanese proboscideans adapted to extreme climatic events in the past; and (ii) use these insights to assess/predict the consequences of adaptability in living elephants. This research also focuses on advancing knowledge of physiological and behavioral adaptations in free-ranging Asian elephants.

Elephants, Anthropocene, and survival

As the earth whirls around the Anthropocene, uncontrolled human activities, along with the earth's dynamic climate, have challenged biodiversity. In this context, to favor fitness and survival, organisms must learn to adapt to extreme changes. This could be particularly challenging for the species that reproduce slowly and have a long lifespan, like elephants. Consequently, due to climatic and human-associated loss of habitats and subsequent population declines, elephants are among the most vulnerable species. The absence of elephants as a keystone species can disrupt the biological functions of an ecosystem and may even lead to its collapse. It is, therefore, a need of the hour to investigate: (i) how species such as elephants are coping (physiologically) with extreme climatic and anthropogenic challenges and (ii) how these physiological adjustments potentially impact their fitness (reproduction and survival) in the long run (Fig.1).

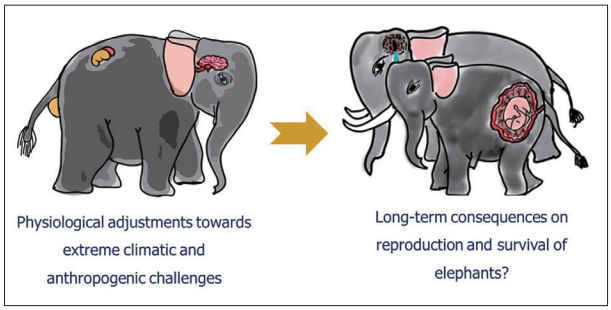

Figure 1. A graphical representation of key questions investigating long-term consequences of physiological adjustments towards extreme climatic and anthropogenic events on reproductive fitness and survival of elephants (Illustrator: Sanjeeta Sharma Pokharel)

Retrospective solutions: Delving into the past

Numerous behavioral and physiological studies, including my research (Pokharel et al., 2017, 2019, 2020; Pokharel and Brown, 2023), hint that elephants are remarkably adaptable to their changing surroundings. However, the long-term consequences and costs of the short-term adjustments remain unknown. Both climatic and anthropogenic effects over generations on long-lived elephants (lifespan ~ 70 years) are challenging to investigate. I plan to study these effects retrospectively by examining how extinct animals, such as proboscideans (a species closely related to elephants), adapted to changing climate at both regional and global scales.

Extinct Japanese proboscideans and their chemical signatures

Categorized based on the presence of a proboscis (trunk), Pro-

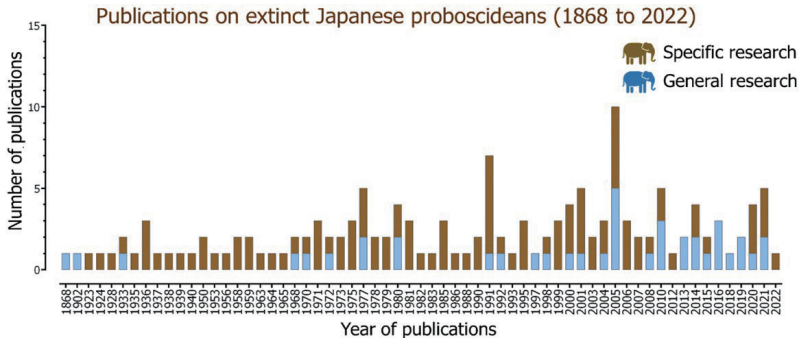

Figure 2. A total number of publications (per year) related to extinct Japanese proboscideans (n = 145), including 105 specific studies and 40 general studies including other species (from 1868 to 2022; Pokharel et al. unpublished data)

boscidea is a group of mammals including three living (extant) elephant species (Asian, African savanna, and African forest elephants) and over 170 extinct species. Fossil records document that the Japanese archipelago once had 11 species of extinct proboscideans belonging to the order of *Elephantoidea* (three different clades and six different families), with *Stegodon aurorae* as an endemic species to Japan from the early Miocene (~23 to 16 million years ago) to the late Pleistocene epoch (extinct around 20000 years ago; Takahashi and Namatsu, 2000).

Most of the studies on extinct Japanese proboscideans focus primarily on the distribution of fossils across Japan, their skeletal anatomy, or taxonomic classifications (Fig. 2), but there are no studies investigating biological or ecological characteristics using isotopic signatures of these proboscidean fossils.

Intriguingly, isotopes (also hormones) in skeletal/hair/dental tissues of an animal provide time-series information about its past climate, mobility, health, and life history. Recent isotopic and hormonal studies on fossilized tusks of woolly mammoths (Cherney et al., 2023) and my research on retrospective stress profiles in tail-hairs of captive Asian elephants in Japan (Pokharel et al., 2021) provide convincing evidence that molecular information in fossils and/or tissues can be successfully used to study past biological events. However, physiological adaptability to past climatic events in extinct animals is rarely studied. Considering limited research on this field, I plan to establish the knowledge base on (i) how past climatic conditions (paleoclimate) influenced, (ii) their movements and foraging choices across habitats (paleo-behavior), and (iii) subsequently affected their health (paleo-endocrinology) and survival, using Japanese proboscidean fossil records and by combining interdisciplinary approaches of measuring isotopes and steroids.

Methods: Reconstructing paleoecology of extinct proboscideans

To understand the paleoecology and decipher the effects of paleoclimate, I plan to measure stable isotopes, such as $\delta^{13}C$, $\delta^{15}N$, $\delta^{18}O$, and 87Sr/86Sr, to reconstruct the paleoclimate and paleo-behavior as proxies of climatic and ecological traits of *Stegodon*, *Paleoloxodon* and *Mammuthus* species across different habitats in Japan. To further strengthen the knowledge base, I will be measuring hormonal signatures in the fossils to understand how paleoclimate influenced different biological traits in extinct Japanese elephants. In addition, I will be collaborating with scientists from Kyoto University and other Universities and museums in Japan to develop novel techniques to measure fossil isotopes, DNA, and hormones.

Merging paleo- and modern- ecology of proboscideans

To advance and draw parallel understandings of paleo- and modern- ecology, I will establish long-term studies related to Asian elephants and other large mammals. The main aim of these studies will be to understand the physiological and behavioural adjustments of past (extinct) and present (extant) species towards climatic and human-induced challenges and to ultimately predict the costs and consequences of these adjustments on the fitness/survival of elephants (Fig. 3).

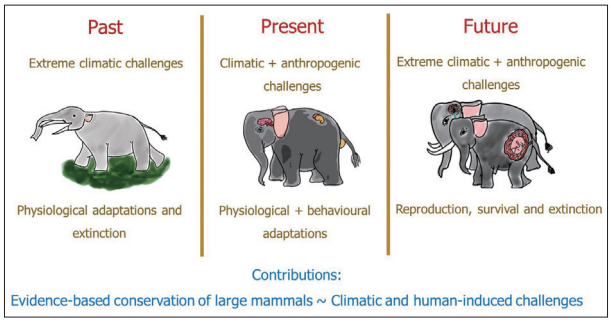

Figure 3. A graphical representation of expected research contributions in the field of paleo- and modern-ecology of proboscideans (Illustrator: Sanjeeta Sharma Pokharel)

References

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