Ecological significance and risks of mineral licks to mammals in a nature reserve on the Eastern Qinghai-Tibet Plateau

Xingcheng He*, Zhixin Wen†, Yujin Wang‡, Anderson Feijó§, Qiang Fu* and Jianghong Ran‡

*Key Laboratory of Bio-Resources and Eco-Environment, Ministry of Education, College of Life Science, Sichuan University, Chengdu, Sichuan, China; †Key Laboratory of Zoological Systematics and Evolution, Institute of Zoology, Chinese Academy of Sciences, Beijing, China; ‡Management Office of the Anzihe National Nature Reserve, Chongzhou, Sichuan, China

ABSTRACT
Mineral licks are important components of terrestrial ecosystems that have special value to the maintenance of fluid balance of mammals, by providing them with essential mineral nutrients such as sodium, calcium, and magnesium. In the Anzihe Nature Reserve, southwest China, seven species of ungulates and one species of primates were frequently observed visiting the mineral licks in high densities. As a consequence, mineral licks have attracted illegal hunters and facilitated the spread of parasites and diseases, leading to a depletion of local populations. Therefore, we suggest that regions with abundant mineral licks should be designated as key protected areas in the Anzihe Nature Reserve and relevant zones for animal health surveillance.

Introduction
Salt licking has been observed in many mammalian species. Such behavior, compensating for mineral deficiencies and imbalances, is exhibited by nearly all herbivorous and omnivorous mammals on Earth (Ayotte, Parker, and Gillingham 2008; Kennedy et al. 1995; Panichev et al. 2017). Regions where wild animals intake mineral-rich soil or water are called mineral licks (Atwood and Weeks 2002). The requirement for essential mineral nutrients (e.g., sodium, calcium, and magnesium) has been widely recognized as the main driver of wildlife’s access to mineral licks (Ayotte et al. 2006; Li et al. 2014).

Mineral licks in the Anzihe Nature Reserve
Anzihe Nature Reserve, located in the easternmost part of the Qinghai-Tibet Plateau, was established in 1993 to protect the Giant Panda (Ailuropoda melanoleuca) and its habitats (Photo. 1.1). So far, at least 10 mineral licks have been recorded in the Anzihe Nature Reserve and its surrounding areas (Photo 1.1). These are wet mineral licks that are associated with groundwater springs or seeps (Ayotte, Parker, and Gillingham 2008). Mineral licks are easily identifiable as areas with little vegetation coverage and numerous animal marks. Within this reserve, mineral licks are often found in sites characterized by animal trails extended in different directions and prominent vegetational change. The sizes of the mineral licks in Anzihe Nature Reserve range from 1 m² to 10 m².

Mineral licks are indispensable resource for the wild animals in the Anzihe Nature Reserve
In the Anzihe Nature Reserve, a 6-year (2016–2021) wildlife monitoring program has recorded eight large or medium-sized mammalian species visiting the mineral licks, including seven species of ungulates (Sambar Deer, Rusa unicolor, Red List of China’s vertebrates category version 3.1: Near Threatened; Takin, Budorcas taxicolor, Vulnerable; Tufted Deer, Elaphodus cephalophus, Near Threatened; Reeves’ Muntjac, Muntiacus reevesi; Chinese Serow, Capricornis milneedwardsii, Endangered; Wild Boar, Sus scrofa, Least Concern; Forest Musk Deer, Moschus berezovskii, Critically Endangered) and one species of primates (Tibetan Macaque, Macaca thibetana, Vulnerable) (Photo 2.1). These animals visited the mineral licks to intake the soil and/or water, which are rich in one or more elements of sodium, calcium, and magnesium (Ayotte et al. 2006). Distinct species usually visited different mineral licks or visited the same mineral lick at different times (Table 1), probably to reduce interspecific competition. We also found that salt licking occurred more frequently in the spring and summer than in the autumn and winter, implying that animals have a stronger requirement for mineral intake during warmer weather. Schultz, Mayland, and Emerick (1988) attributed the frequent use of mineral licks by ungulates in the spring to the high intake of potassium in forage, which impedes absorption of sodium and magnesium and causes diarrhea. Actually, this phenomenon has also been found in previous studies on ungulates (Hebert and Cowan 1971; Klaus and Schmidg 1998). For
mammals, replenishing sodium and magnesium by salt licking can offset high potassium ingestion during the spring (Ayotte et al. 2006; Klein, Froelich, and Krief 2008). In our study area, we did observe a higher frequency of diarrhea in Sambar deer and Takin in the spring (Photo 2.2b), which may lead to their higher frequency of salt licking. Additionally, the higher utilization of mineral licks in the summer may result from species’ additional mineral requirements during gestation and lactation (Ayotte, Parker, and Gillingham 2008). Indeed, our monitoring indicated that female Sambar Deers lick more frequently in spring and summer than males.

Besides, mineral licks play a significant role in the social life of mammals. For Sambar deer, males and females have similar daily rhythms of salt-licking behavior (the males presented two peaks at 19:00 ~ 21:00 and 4:00 ~ 7:00, while females had their peak activity at 22:00~5:00) (He et al. 2019). Mineral lick can increase
Table 1. Utilization of six mineral licks by different mammalian species in the Anzihe Nature Reserve during 2021.1–2021.12, measured as the number of independent photos for each species (photos of the same mammalian species were considered as independent if separated by at least 30 minutes).

| Species/No. of mineral licks | NO. 1 | NO. 2 | NO. 3 | NO. 4 | NO. 5 | NO. 6 |
|------------------------------|-------|-------|-------|-------|-------|-------|
| Tibetan Macaque              | 0     | 0     | 0     | 0     | 0     | 1     |
| Wild Boar                    | 3     | 29    | 10    | 20    | 20    | 7     |
| Sambar Deer                  | 705   | 345   | 286   | 564   | 162   | 586   |
| Musk Deer                    | 0     | 0     | 1     | 0     | 0     | 2     |
| Tufted Deer                  | 0     | 1     | 5     | 0     | 0     | 0     |
| Reeves’ Muntjac             | 0     | 0     | 1     | 0     | 0     | 0     |
| Chinese Serow               | 0     | 0     | 3     | 5     | 0     | 0     |
| Takin                        | 44    | 14    | 1     | 0     | 2230  | 0     |
| Sum of camera days           | 265   | 251   | 304   | 140   | 314   | 153   |

Photo 2.2. Feces from (a) a healthy individual of sambar deer (found in summer) and (b) a sambar deer with severe diarrhea (found in spring). Photo by Xingcheng He.

Photo 2.3. (a) Sambar deer’s (*Rusa unicolor*) courtship behavior, (b) Tibetan macaque’s (*Macaca thibetana*) mating behavior, and (c) Takin’s (*Budorcas taxicolor*) mating behavior in the mineral licks in the Anzihe Nature Reserve. Photo by Infrared camera (installer: Honghan Ma, Yujin Wang, Xingcheng He).
their opportunities to encounter and hence the reproductive success rates (Photo 2.3a). The mineral licks further facilitate the mating behaviors of other mammals, as seen in Takin and Tibetan macaque (Photo 2.3b, c). In this sense, mineral licks are ideal regions to study animal behavior and demography dynamics.

Risks of mineral licks for mammals

The high concentration of animals in mineral licks poses additional conservation concerns and risks. The risks come from both predators and humans (Klaus and Schmidg 1998). Mineral licks can attract predators due to elevated prey densities (Griffiths, Gilmore, and Bowler 2020), yet large predators in the Anzihe Nature Reserve are generally rare. Illegal hunters are thus the greatest threat to the animals visiting the mineral licks in the reserve. According to our survey, hundreds of animal traps were set in the mineral licks and surrounding areas (Photo 3.1 and Photo 3.2). In addition, high animal density may lead to accumulation of feces and urine at mineral licks that are being ingested together with mineral-rich soil and water, making parasites and diseases spread more extensively (Johnson et al. 2011; Klaus and Schmidg 1998). Our interview survey showed that there was once a large-scale disease outbreak for Chinese Serow in the Anzihe Nature Reserve, which caused severe population decline of the species. Despite being a typically solitary species, individuals of Chinese Serow share the mineral licks. Therefore, mineral licks may be important plague-spreading places.

Conclusions and conservation implications

Mineral licks, as a significant part of the physiological and social life of mammals, can provide mammals with essential elements such as sodium, calcium, and magnesium and unique opportunities for mating. As a result, mineral licks are ideal places to study animal behavior and the demographic structure of solitary and rare species. However, the high density of mammals and easy access to mineral licks attracted poachers and facilitated the spread of parasites and
diseases, leading to species population decline. We therefore strongly suggest that the mineral licks and surrounding areas should be designated as key protected areas in the Anzhihe Nature Reserve and zones of animal health surveillance. Furthermore, it is necessary to carry out regular monitoring of bacteria and parasites around the mineral licks. Finally, the photos and videos of wildlife in the mineral licks can be used for future scientific research (e.g., exploring the relationship between the utilization frequency of mineral licks by different animals and their chemical compositions) and nature education, which are crucial to protecting the local mammalian fauna.

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Disclosure statement

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