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RESEARCH ARTICLE

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Behavioral patterns of captive alpine musk deer: sex-specific behavior comparisons

Abstract The aim of this study was to document the behavior of captive alpine musk deer and to determine if daily behavior patterns varied between females and males. From August 2002 to January 2003, focal sampling was used to observe 32 adult captive alpine musk deer (13 female and 19 male) at Xinglongshan Musk Deer Farm (XMDF), Xinglongshan National Nature Reserve, Gansu Province. Results indicated similar behavior patterns for males and females, with only two out of 12 recorded behaviors showing significant sex differences. In comparison to females, males rested for a longer duration and exhibited tail pasting more frequently. This study also provided the first recording of tail pasting by female musk deer.

Keywords alpine musk deer (*Moschus sifanicus*), behavior pattern, captivity, sex difference

1 Introduction

The Alpine Musk Deer (*Moschus sifanicus*) is endemic to Qinghai-Tibet Plateau, where it inhabits coniferous forests and deciduous forests at an elevation of 3000–5000 m. As a result of overharvesting and illegal poaching for musk, the population has been declining, with a current estimate of less than 100000 individuals (Sheng and Ohtaishi, 1993). Alpine musk deer has been listed on the Appendices I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and protected as a Category I key species in China.

Since 1958, captive farming has been conducted to conserve the wild population and utilize musk deer resources (Homes, 1999). The Xinglongshan Musk Deer Farm (XMDF) was established in 1990 at the Xinglongshan National Nature Reserve, Gansu Province, Northwest China, and houses approximately 300 deer. Over time, major improvements have been made in the techniques of captive breeding, and most importantly, the sustainable extraction of musk from the live male deer (Jiang, 1998). However, the issues of high mortality, low musk production, and shortened life span for musk secretion remain to be solved before sustainable utilization of musk deer resources can be achieved (Homes, 1999; Parry-Jones and Wu, 2001; Meng et al., 2003).

To assist in providing more appropriate management practices, a thorough understanding of behavioral characteristics is required. Behavior is likely to vary with individuals and sex; as such, an understanding of sex-specific behavior traits may assist in improving management techniques and practices. Therefore, this study was to compare male and female behavioral patterns measured by the behavioral frequency and duration of captive musk deer to explore behavioral patterns in relation to sex.

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2 Materials and methods

2.1 Animals, housing, and managing

This study was conducted at the Xinglongshan Musk Deer Farm (XMDF), Xinglongshan National Nature Reserve, Gansu Province, China. Located at an elevation of 2000–2100 m, the reserve has a continental mountain climate with short cool summers and long harsh winters. January is the coldest month with an average and minimum temperature of 9°C and −28°C, respectively. The warmest

month is July, averaging 14°C. Rainfall is mainly in July, August, and September, with an annual precipitation of 48–62.2 mm.

A total of 32 captive adult alpine musk deer were studied at XMDF, including 19 males and 13 females. All deer were captive born and were housed at XMDF for at least 2 years prior to this study. Five to seven individuals were housed in an outdoor yard measuring 10 m×10 m, from which seven brick cells, measuring 2 m×2 m with wall height of 2 m were attached.

Five to eight enclosures were lined up in a row separated by an iron-mesh fence, which enables olfactory and auditory communication between neighboring inmates but prevents physical contact. No communication was possible between rows. Animals were maintained by a keeper and were fed twice a day, at dawn and dusk, on a diet of fresh leaves (May to November) or dried leaves (December to April). Leaves of the preferred forage species, predominantly *Crataegus kansuensis* and *Acer tetramerum* et al., were collected from the Xinglongshan National Nature Reserve, a habitat for wild musk deer. This diet was supplemented with artificial feeds containing approximately 40% corn, 25% wheat, and 25% bean, which was mixed onsite. Seasonal vegetables were also provided opportunistically, and water was provided *ad libitum*. Diet manipulation was not possible for our study as all experiments were conducted at a commercially operating deer farm. However, food provisions remained consisted within each season.

During the study, males and females were housed separately from March to October. From November to February, one male was introduced into each of the female enclosure, as with commercial breeding practices. All animals were individually identified by the numbered plastic ear tag.

2.2 The ethogram and the behavior sampling

On the basis of previous behavioral studies (Zhang, 1979; Green, 1986, 1987; Sheng and Ohtaishi, 1993) and preliminary observations, an ethogram was established for captive alpine musk deer (Table 1).

Table 1 Ethogram of selected behaviors for captive alpine musk deer

behavior	definition
resting, RE	lying on the ground and in inactive and relaxed state
standing-alert, SA	standing still, ears pointed, alert and gazing at stimuli or potential stimuli
locomotion, LO	moving without any accompanying behaviors
feeding/drinking, FD	feeding or drinking
ruminating, RU	expressing typical series of rumination behavior, i.e., chewing, swallowing, and regurgitating
tail-pasting, TP	rubbing the tail and scent-marking on the surface of the wall or doorframe
urinating/defecating, UD	full or partial exhibiting of a series of activities such as earth-scratching, urinating, and pellet covering
environmental sniffing, ES	exploring the wall or ground with nose
ano-genital sniffing, AS	sniffing or licking the ano-genital region of another deer
self-directed behavior, SD	expressing activities directed to itself, including self-grooming with mouth, self-scratching, and other self-directed behaviors
affinitive interaction, AI	direct physical contact between animals without obvious aggression i.e., mutual grooming, nursing, and licking
agonistic interaction, CI	obvious aggressive behaviors with or without direct body contact i.e., fighting, chasing, and attacking with projected canines (in males)
miscellaneous behavior, MB	all other behaviors that occurred at very low frequency and duration i.e., nursing fawns

2.3 Data collection and statistical analysis

Due to lighting restrictions, behavioral observations were recorded during daylight hours with the assistance of binoculars (10×42°) to confirm individual ear tag numbers. To measure behavioral frequency and duration, a focal musk deer was selected randomly from a group, and its behaviors recorded continuously for five minutes. A single researcher conducted these observations ten times a day at three times a week for a total of six weeks over a period of six months.

The frequency and duration of each behavior were recorded with the monthly averages and standard errors (SE) calculated for each individual. The total observations of behaviors were under five minutes in duration, which were excluded from analysis.

The Mann-Whitney U Test was used to test the potential differences between males and females. Statistic analysis was conducted with the SPSS11.0 (SPSS Inc., Chicago, Illinois) using two-tailed probability of $P = 0.05$ significance level.

3 Results

3.1 The comparison of behavioral frequency between female and male musk deer in captivity

The comparison of behavioral frequency between female and male captive musk deer is shown in Fig. 1. Females rested (0.84±0.43) more frequently than males (0.71±0.41) ($P < 0.05$), and males recorded significantly higher frequency of the tail-pasting behavior (0.23±0.08) than females (0.04±0.02) ($P < 0.01$). All other behaviors

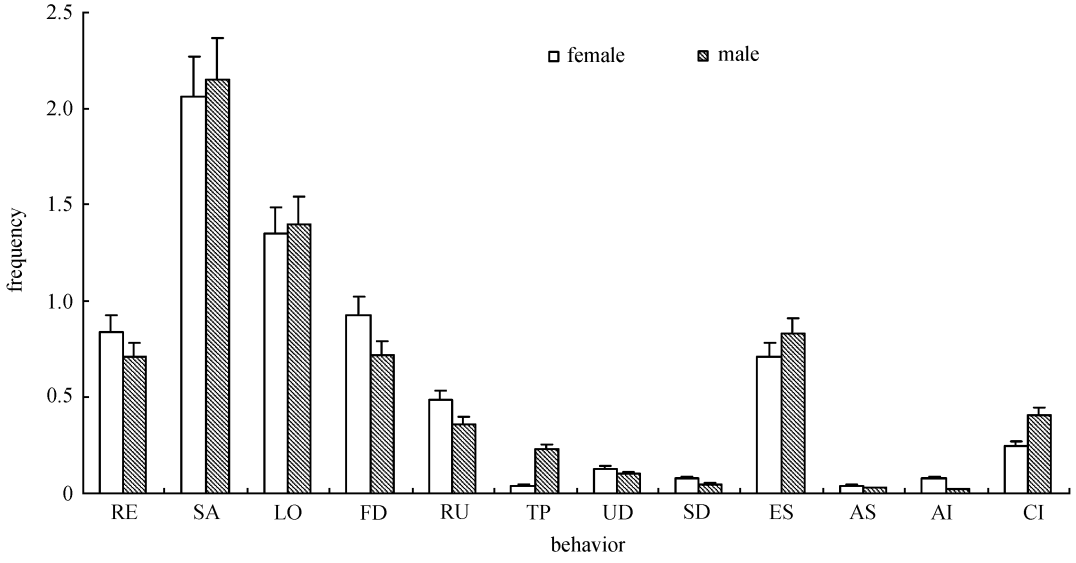

Fig. 1 The comparison of the behavioral frequency between female ($n = 13$) and male ($n = 19$) musk deer
Note: Behaviors include resting (RE), standing-alert (SA), locomotion (LO), feeding/drinking (FD), ruminating (RU), tail-pasting (TP), urinating/defecating (UD), self-directed behavior (SD), environmental sniffing (ES), ano-genital sniffing (AS), ano-genital sniffing (AS), affinitive interaction (AI), and agonistic interaction (CI).

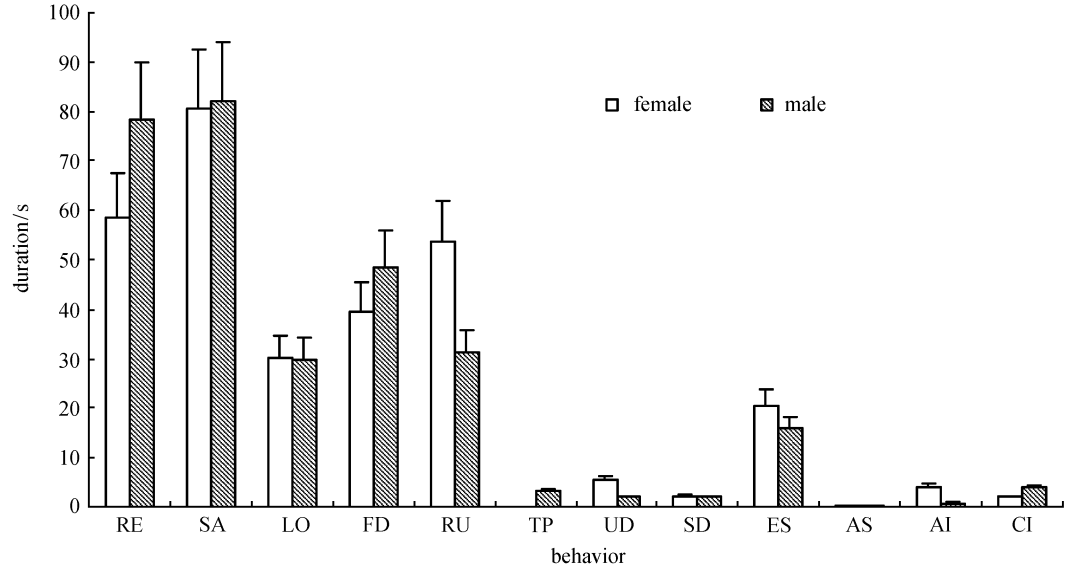

Fig. 2 The comparison of the behavioral duration between female ($n = 13$) and male ($n = 19$) musk deer
Note: Behaviors include RE, SA, LO, FD, RU, TP, U, SD, ES, AS, AS, AI, and CI.

recorded a similar frequency between females and males ($P > 0.05$).

3.2 The comparison of behavioral duration between female and male musk deer in captivity

As shown in Fig. 2, male musk deer demonstrated significantly longer duration of resting (78.33±11.86 s) and tail pasting (3.34±1.22 s) than females (RE, 58.60±10.57; TP, 0.01±0.01) (RE, $P < 0.05$; TP, $P < 0.01$). All other behavioral differences between female and male musk deer were insignificant ($P > 0.05$).

4 Discussion

Wildlife has evolved in a unique array of behavioral characteristics that have contributed to their survival and reproduction in specialized environmental niches. In captivity, behavior provides an essential mean by which

animals can exist within a confined and artificial environment (Price, 1998). Such behavior analysis provides an opportunity to improve management practices within captive farms. Alpine musk deer are notoriously difficult to manage in captivity due to their solitary habits, territorial behavior, and excitable nature (Green, 1987). Findings from our study indicated both sexes frequently exhibited vigilant behavior, characterized by standing alert and locomotion. Such increased vigilance is most likely related to the increased social stress placed on this animal, which is solitary in nature (Green, 1986).

With regard to sexual specific behavior patterns, our preliminary observations indicated the frequency and duration of behaviors were similar for male and female captive alpine musk deer, with only resting and scent marking behaviors showing significant variations. Such results are not unexpected given the uniform management practices imposed on both sexes, despite housing in separate enclosure during rut season. However, the results have been found in wild feral goats (*Capra hircus*) also by Shi et al. (2003), who reported no significant differences in general activity between adult male and female. While Meng et al. (2006) found no evidence of domestication behavior traits, in comparison with wild and captive born musk deer; further studies in the wild are recommended to assess if the general similar behavior traits are similar between males and females in the wild or an artifact of the captive environment.

Resting behavior was significantly different between sexes wherein females recorded a high frequency, while males showed a higher duration. Previous studies of forest (Zhang, 1979) and alpine musk deer (Green, 1986) support these findings, with females described as more restless than males, which is more sedentary during nonrut periods. The authors suggest these characteristics are due to different energy utilization patterns (Zhang, 1979; Green, 1986).

While reproductive season was not measured directly in our study, it should be investigated to assess the role. Musk deer are a small solitary forest ruminant, which inhabits steep, forested, or shrub-covered slopes, mainly in the subalpine zones of mountain regions (Green, 1987) where the dense undergrowth of rhododendron, bamboo, and other shrubs forms the typical habitat. As such, musk deer have a highly developed olfactory signaling system, with scent used as a primary means of communication. Green (1987) and Sokolov (1984) defined tail pasting as male-specific scent marking behavior. Our results, however, indicated female alpine musk deer at XMDF also did exhibit tail-pasting during the year. Sexual experienced females were observed performing this male specific behavior between mating bouts, although its behavioral mode differed from that of males. Females were recorded pasting their tail and ano-genital region against a projected surface such as the doorframe of enclosure for a relatively short time period, whereas males recorded a more obvious movement of up-down and left-right for a longer time period, enabling clear recognition for the behavior. The frequency of tail pasting in males was significantly higher than that in females, concurring with findings of the closely related forest deer (*Moschus bererovskii*) (Sheng and Ohtaishi, 1993). The exhibition of this behavior by female musk deer, however, requires further investigation to determine the underlying mechanism, its specificity to musk deer species and whether it is a redundancy behavioral characteristic of captive individuals.

In conclusion, our preliminary observations indicated little differences between male and female captive alpine musk deer, suggesting sex-specific management is not necessary for captive animals. Further investigations relating to reproductive seasons and comparisons with wild conspecifics are recommended to better understand the behavior of these relatively unknown species.

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References

Green M J B (1986). The distribution, status and conservation of Himalayan musk deer. Biological Conservation, 35: 347–375

Green M J B (1987). Scent marking in the Himalayan musk deer. Journal of Zoology, 1: 721–737

Homes V (1999). On the Scent: Conserving musk deer, the uses of musk and Europe's role in its trade. TRAFFIC Europe

Jiang Y W (1998). The reproduction of the captive Alpine musk deer. Chinese Journal of Zoology, 21: 23–25 (in Chinese)

Meng X X, Yang Q S, Xia L, Feng Z J, Jiang Y W, Wang P M (2003). The temporal estrous patterns of female alpine musk deer in captivity. Applied Animal Behavior Science, 82: 75–85

Meng X X, Zhou C Q, Hu J C, Li C, Meng Z B, Feng J C, Zhou Y J, Zhu, Y J (2006). The musk deer farming in China. Animal Science, 82: 1–6

Parry-Jones R, Wu J Y (2001). Musk Deer Farming as a Conservation Tool in China. Hong Kong: TRAFFIC East Asia

Sheng H, Ohtaishi N (1993). The status of deer in China. In: Ohtaishi N, Sheng H L, eds. Deer of China: Biology and Management. Amsterdam: Elsevier Science Publishers

Shi J B, Dunbar R I M, Buckland D, Miller D (2003). Daytime activity budgets of feral goats (*Capra hircus*) on the Isle of Rum: influence of season, age, and sex. Canadian Journal of Zoology, 81: 803–815

Sokolov V E (1984), Chemical communication of some species of rodents, ungulates and carnivores. Acta Zoological Fennica, 171: 67–69

Zhang B L (1979). The Taming and Raising of Musk Deer. Beijing: Agriculture Press (in Chinese)