Iranian Journal of Veterinary Research, Shiraz University, Vol. 13, No. 4, Ser. No. 41, 2012

Behavior pattern as the indicator of reproductive success of Alpine musk deer

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(Received 22 Jun 2011; revised version 7 Apr 2012; accepted 2 Jul 2012)

Summary

To establish the behavioral indicator of reproductive success of female captive Alpine musk deer (*Moschus sifanicus*), the focal sampling was used to record the individual behaviors at Xinglongshan Musk Deer Farm (XMDF), Gansu province, China. Conducted between June 2008 and January 2009, 31 adult females were observed, of which 26 had successfully bred in the previous year, and five of which were barren. The frequencies of 12 behaviors were recorded and compared to explore variation in reproductive success and general behavior patterns. The results showed that there were differences in behavioral frequencies between females barren and fawned in the previous year. Compared to successful individuals, barren females expressed environment sniffing more frequently during non-mating season, but less frequently during mating season ($P<0.05$). Females which had previously fawned expressed ano-genital sniffing less frequently than barren females in non-mating season ($P<0.05$). Furthermore, both female groups elicited the male specific tail-pasting behavior, although the demonstration levels were not different significantly between both. The above behavioral differences have implications for musk deer farming practices, whereby females should be grouped and separated by their previous reproduction history, to maximize future reproductive success.

Key words: In captivity, Alpine musk deer (*Moschus sifanicus*), Female, Behavioral frequency, Reproduction success

Introduction

Musk deer (*Moschus* spp.) are well known for the production of musk, a highly valued ingredient used in some perfumes and Asian traditional medicine (Aryal *et al*., 2010; Aryal and Subedi, 2011). The Alpine musk deer, endemic to the Tibet-Qinghai Plateau of China, is distributed throughout the plateau and within adjacent mountainous regions of western China. Due to a combination of historic illegal musk hunting, habitat loss and habitat degradation, populations of wild Alpine musk deer have been declining for decades (Yang *et al*., 2003). The species is currently endangered and is listed into Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and near threatened on the World Conservation Union IUCN Red list (last assessed in 1996), whilst in China it is protected under the Wild Animal Protection Law 1988 as a Category I key species.

Since the 1950s, captive farming has been employed in China to conserve and sustainably utilize musk deer resources (Homes, 1999). Although early commercial expansion was encouraged, musk deer farming has proved difficult in practice due to the reduced birth and survival rates of captive born fawns (Parry-Jones and Wu, 2001). To preserve Alpine musk deer population and extract musk from live animal, the Xinglongshan Musk Deer Farm (XMDF) was established in the Xinglongshan National Nature Reserve, Gansu Province, China, in 1990. As with many farms, conservation success at XMDF has been limited due to a high number of barren or reproductively unsuccessful females, reducing the reproduction rate of

Alpine musk deer farming and increasing maintenance costs (Parry-Jones and Wu, 2001; Meng *et al*., 2006).

Behavior is one of the important aspects of reproduction, and hence, an understanding of behavioral characteristics may assist to improve management practices leading to greater reproductive success. Previously, however, the behavior pattern of Alpine musk deer was not well known due to its solitary nature and closed habitat, and also, important factors which influence musk deer breeding in captivity. Currently, most knowledge about Alpine musk deer is from descriptive observation (Wu and Wang, 2006; Sheng and Liu, 2007), while detailed behavioral characteristics remain poorly understood, and studies of behavioral differences are sparse. To develop successful musk deer farm breeding programs, behavioral patterns should be explored in further detail.

This study will explore the behavioral differences between females with different reproduction success, to provide a better understanding of how behavioral characteristics and accompanying activity budgets contribute to reproductive success. The data may have important implications to the future success of musk deer farming in China.

Materials and Methods

This study was conducted at Xinglongshan Musk Deer Farm (XMDF) of Xinglongshan National Nature Reserve, a region of western China (358N, 1048E). Located at an elevation of 2000~2100 m, the reserve has a continental mountain climate with short, cool summers and long, harsh winters. Average temperatures are coldest in January (9°C), and warmest in July (14°C), with annual precipitation of 48~62.2 mm.

Thirty-one adult female Alpine musk deer, including 5 females which were barren in the previous year (BP) and 26 females which had fawning in the previous year (FP) were observed between June 2004 and July 2005. All animals were born and raised in captivity at XMDF. Groups of up to seven individuals were housed in an outdoor exercise area (100 m^2), with unrestricted access provided to six adjoining indoor brick cells (4 m^2). Neighboring enclosures were separated by wire mesh, enabling olfactory and auditory communication between individuals, but prevented physical contact. Animals were fed twice daily, 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, *Crataegus kansuensis* and *Acer tetramerum*, were collected from the Xinglongshan National Nature Reserve, a habitat for wild musk deer. This diet was supplemented with artificial feed containing approximately 40% corn, 25% wheat, and 25% beans, which was mixed onsite. Seasonal vegetables were also provided opportunistically and water was provided *ad libitum*. Diet manipulation was not possible in this study, as all experiments were conducted at a commercially operating musk deer farm; however, food provisions were consistent throughout the study.

In line with commercial breeding practices, male and female musk deer were housed separately from March to October, during non-mating season. At the commencement of rut season (November to March), one male was introduced into each of the female enclosures, and removed after the completion of the female estrus cycle. All animals were individually identified by numbered plastic ear tag.

On the basis of previous behavioral studies (Sheng and Liu, 2007), and preliminary observations, the following ethogram was established for captive musk deer:

Resting (RE): Animal is lying on the ground and in inactive and relaxed state.

Vigilance (SA): Animal is still, alert and gazing at stimuli.

Locomotion (LO): Animal is moving without any accompanying behaviors.

Feeding (FD): Animal is ingesting fresh or dried leaves, artificial feed or drinking water.

Ruminating (RU): Animal expresses typical behavioral series of rumination, i.e., chewing, swallowing and regurgitating.

Tail-pasting (TP): Animal expresses scent mark by rubbing the base of the tail in circular movement on the surface of a wall or doorframe.

Defecating-urinating (UD): Animal fully or

partially exhibits activities such as squatting on hind legs, earth-scratching, urinating, defecating and covering pellets by scratching behavior observed both in association and isolated from latrines.

Environmental sniffing (ES): Animal explores the wall or ground with its nose.

Ano-genital sniffing (AS): Animal sniffs or licks the ano-genital region of another musk deer.

Self-directed behavior (SD): Animal expresses activities directed to itself, including self-grooming with mouth, self-scratching etc.

Affinitive interaction (AI): Direct physical contact between adult animals without obvious aggression i.e., mutual grooming, sniffing, licking.

Agonistic interaction (CI): Aggressive behaviors with or without direct body contact, including chasing, striking with forelegs, or canines (males).

Miscellaneous behavior (MB): All other behaviors with infrequency, such as stereotypic behaviors.

At XMDF, Alpine musk deer fawning occurs from June to July, mating occurs from November to February, and weaning of calves is conducted in October (Meng *et al*., 2003a, b). Henceforth, during this study, the observation period was defined as "non-mating season" (August to October) and "mating season" (November to January). Due to lighting restrictions, behavioral observations were recorded during daylight hours with the assistance of binoculars (10 × 42°) to confirm individual ear tag numbers. Focal sampling and occurrence recording was utilized to observe behavior (Altman, 1974). To measure behavioral patterns, a focal female musk deer was selected randomly from a group and its behaviors recorded continuously for 5 min, before observing the next randomly selected deer. Observations were conducted four times a day, three days a week by a single researcher. Over a six month period, a total of 175 h of observations were collected.

The frequency of each behavior was calculated, with seasonal averages (mean±SEM) compared for each animal and for BP and FP females. Behaviors were standardized by individual and number of samples, respectively. Due to the in-frequency and variable nature, mis-cellaneous behaviors (MB) were excluded from analysis. As females were housed together during the whole study period and thus behavioral data were not independent, the Wilcoxon Signed Rank Test was utilized to explore behavioral differences. Statistic analysis was conducted with SPSS 11.0 software (SPSS Inc., Chicago, Illinois), using two tailed probability, with a significance level of $P \leq 0.05$.

Results

As shown in Fig. 1, BP females demonstrated self-directed behavior, environmental sniffing and ano-genital sniffing significantly more frequently than FP females ($P<0.05$). All other behavioral differences were insignificant.

The behavioral differences between BP and FP female musk deer during mating period were shown in Fig. 2. FP females expressed environmental sniffing sig-nificantly more frequently than BP females ($P<0.05$). No other behavioral patterns were statistically significantly different.

Discussion

Musk deer are solitary and territorial in nature, inhabiting shrub-covered slopes in the sub-Alpine zones of mountain regions. As such olfactory signaling between individuals is the primary means of communication, faeces and urine are utilized as scent markers (Sheng and Liu, 2007). Scent cues are also evident for captive musk deer, which are observed defecating repeatedly at a single site, and covering pellets with hooves, containing interdigital glands (Sheng and Liu, 2007; Meng *et al*., 2011). The captive environment contains cues such as the identity, location and potential reproductive status of an individual, which are available through environmental sniffing. At XMDF, captive musk deer mark scents at a number of sites throughout the enclosure through urination, defecation, tail-pasting and pellet-covering, with females frequently moving about to collect information about the environment and other individuals (Meng *et al*., 2003a).

Wu and Wang (2006) reported that the information collecting behavior such as environment sniffing is common in captive musk deer, and sniffing frequency is higher in mating season than in non-mating season. These activities, however, also have a high energy cost. Meng *et al*. (2003a, b) reported that, during non-mating season, females should reduce activity to prepare for the up coming reproduction and compensate for energy lost during previous pregnancy, parturition and lactation seasons. In this study, FP females expended a higher proportion of energy than BP females over the same time period, hence it is more necessary for FP females to reduce high energy expenditure behaviors in order to conserve energy. Our results support these findings as compared to the FP females, BP expressed environment sniffing more frequently during non-mating season, but less frequently during mating season. Similar results have been reported in captive forest musk deer (*Moschus bererovzkii*) (Sheng and Liu, 2007).

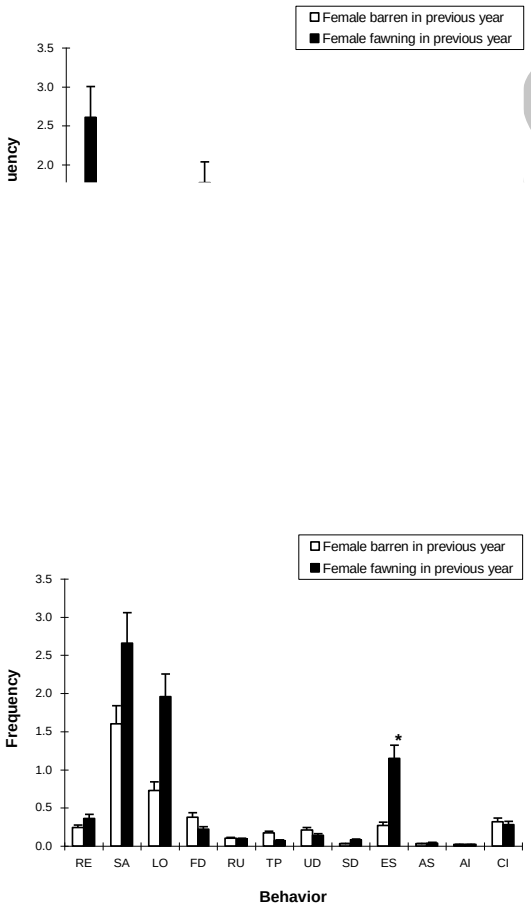

Fig. 2: Behavioral frequency of BP and FP females during mating season. *Significant difference (P<0.05)

For captive animals, behavior modulation is an important aspect of social interactions, manifested during reproduction (Galina *et al*., 1996). During the reproductive season, social olfactory behavior may contribute to reproductive synchrony, for example, unmated females *Bison bison* use olfactory cues to explore reproductive status of other females prior to their own estrus, but not after (Berger, 1992). In addition, the animals of a captive herd can exert a certain influence over the behavior of their herdmates by causing behavioral imitation in others. Meng *et al*. (2003a) reported that there exists obvious reproduction synchrony and timing in captive female Alpine musk deer at XMDF owing to the seasonal environment. Meng *et al*. (2003b) also predicted that social interactions such as ano-genital sniffing among female musk deer could serve as a social modulating factor. Generally speaking, the temporary pattern of reproduction of BP female was out of the normal range, therefore BP female may adjust its reproduction timing through social behaviors, such as ano-genital sniffing, which assists in collecting information from the other individuals, specifically FP females (Meng *et al*., 2003a, b). Similarly, our data indicated that BP females expressed ano-genital sniffing more frequently than FP females during non-mating season.

Tail-pasting is one of the most important scent marking behaviors of musk deer, and has been defined as the male specific scent marking behavior (Homes, 1999; Sheng and Liu, 2007). The caudal gland of the male occurs as a thickening at the base of the short tail and exudes a viscous yellow secretion, with an offensive odor. Typically, wild male musk deer rub the base of their tail throughout their home ranges, against the stems of bushes or dried herbs and grasses (Sheng and Liu, 2007). Our results showed that captive female Alpine musk deer exhibit this behavior during mating season, the frequency of this behavior, however, was not significantly different between BP and FP females. Whilst female tail pasting behavior was observed in this study the frequency and intensity were

relatively less when compared to that observed in captive male musk deer. More thorough studies, however, should be conducted to decide whether females, especially BP females in this study, increased the scent marking through this behavior, or if it is the result of abnormal behavior development in a captive environment.

To some extent, self-directed behaviors of captive animal could be considered abnormal in behavioral analyses, as these behaviors are directed not to other individuals, but to itself (Sheng and Liu, 2007). In this study, BP female demonstrated more self-directed behavior, such as self-grooming, self-scratching, yawning and body stretching etc., than FP females during non-mating season. Namely, FP females expressed less abnormal behavior than BP females, which was similar to Mallapur *et al*.'s findings (2006), in which the levels of abnormal behavior exhibited by captive lion-tailed macaques (*Macaca silenus*) were found to be related to their ability to breed, and proven breeders exhibit significantly less abnormal behavior.

In conclusion, there existed differences of behavioral frequencies between BP and FP female musk deer. BP females demonstrated environment sniffing and ano-genital sniffing more frequently than FP females during non-mating season, and FP expressed environment sniffing more frequently than BP females during mating season. Moreover, females elicited the male specific tail-pasting behavior, which has not previously been described. In regards to musk deer farming practice, the above behavioral differences could be considered, especially the implications of reproductive synchrony, where female individuals should be grouped by reproduction success in the previous year.

Acknowledgements

This study was financially supported by Nature Science Foundation of China (31170364), the "985 Project" of Minzu University of China (MUC98504-14, MUC98507-08) and Program for New Century Excellent Talents in University (NCET-08-0596).

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