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Behavioral Differences Between Captive Female Alpine Musk Deer with Different Reproduction Success in Previous Year

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Abstract: Against a background of poor breeding success in captive alpine musk deer, an understanding of the behavioral differences between captive female alpine musk deer with and without reproduction success in previous year may yield useful information for musk deer farming practice. This study was conducted in the musk deer farm of Xinglongshan National Nature Reserve, Gansu province of China from June 2004 to January 2005. The focal sampling and all occurrence recording was used to observe the behaviors of 38 female alpine musk deer (*Moschus sifanicus*) in which 5 were barren in previous year and 33 females were bred in previous year. The durations of 12 behaviors such as environment-sniffing, etc. were recorded and the behavioral patterns were compared to explore the differences. The results showed that compared to females barren in previous year, the females bred in previous year was more active, pugnacious and explorative in mating season and expressed less self-directed behavior during non-mating season. The data from the present study should contribute to a better understanding of behavioral differences between females with different reproduction success.

Key words: In captivity, alpine musk deer (*Moschus sifanicus*), female, behavioral duration, reproduction success

INTRODUCTION

Musk deer (*Moschus* sp.) is well known for the production of musk, a highly valued ingredient of perfumes and some Chinese traditional medicines which is secreted only by the adult male. Musk deer occurs in at least 13 countries in South Asia, East Asia and eastern Russia with populations currently in decline as a result of habitat loss and intensive illegal hunting for musk (Homes, 1999). The Alpine musk deer is a species of the genus *Moschus* and endemic to the Tibet plateau of China, mainly scattered on the plateau and in adjacent mountainous regions of western China.

Now this species is endangered and threatened with extinction (Yang *et al*., 2003) and is listed into Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and World Conservation Union IUCN Red list (near-threatened, last assessed in 1996) moreover, protected under the Wild Animal Protection Law 1988 as a category I key species in China. Since 1958, captive farming has been employed in China to conserve and sustainably utilize musk deer resources (Homes, 1999; Parry-Jones and Wu, 2001) from then on, efforts have been made to expand musk deer farming and many farms have been established but raising musk deer has been mostly unsuccessful due to the difficulties of breeding under captive conditions and the low rate of reproduction (Zhang, 1979; Homes, 1999). 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 of China in 1990 however, many problems have been existing in alpine musk deer farming for example, some female alpine musk deer have been raised for years but did not breed successfully which directly reduce the reproduction rate of alpine musk deer farming and increases the cost of maintenance (Parry-Jones and Wu, 2001; Meng *et al*., 2006).

Behavior is one of the most important aspects of reproduction and an understanding of characteristics of behavior can lead to management applications that can improve reproductive success. However, the behavior of alpine musk deer has received little study because of its solitary and closed habitat which is one of the important factors to influence the musk deer breeding in captivity. Now, the limited knowledge on the behavior of alpine musk deer was attained mainly through descriptive observation (Zhang, 1979; Wu and Wang, 2006) but more detailed behavioral characteristics of captive musk

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deer remain poorly understood and studies of behavioral differences are sparse. To develop farming of this species of musk deer, a comparative study on the behavioral differences between females with different reproduction success is of importance. Here, researchers quantified the behavioral patterns of female musk deer and examined the differences between females barren and bred in previous year on the basis of which potential suggestion was given to improve the musk deer farming.

MATERIALS AND METHODS

Animals, housing and managing: This study was conducted at Xinglongshan Musk Deer Farm (XMDF), Xinglongshan National Nature Reserve, Gansu province in northwestern China. 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. About 38 adult female alpine musk deer including 5 female Barren in Previous year (BP) and 33 female Fawning in Previous year (FP), all of which were born and raised in captivity at XMDF were observed over a 6 month period from June 2004 to January 2005. Groups of up to seven, individuals were housed in outdoor exercise area (100 m^2) with unrestricted access provided to 6 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-November) or dried leaves (December-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. Males and females musk deer were housed separately from March-October during non-mating season. In line with commercial breeding practices at the commencement of rut season (November-March), 1 male was introduced into each of the female enclosure and then taken back to its original enclosure after the female ended estrus. All animals were individually identified by numbered plastic ear tag.

Ethogram and the behavior sampling: On the bases of previous behavioral studies (Zhang, 1979; Sheng and Ohtaishi, 1993; Green, 1987) and preliminary observations from June 2004 to July 2005, the ethogram was established for captive female alpine musk deer (Table 1).

Data collection and statistical analysis: At XMDF, alpine musk deer fawning occurs from June-July, mating occurs from November-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-October) and mating season. Due to lighting restrictions, behavioral observations were recorded during daylight hours with the assistance of binoculars (10×42°) to confirm individual ear tag numbers. The focal sampling and occurrence was utilized to observe and record behavior (Altmann, 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 until all musk deer had been observed. A single researcher conducted these observations 4 times a day, 3 times a week, over a period of 6 months for each animal with a total of 175 h

Table 1: The ethogram and the behavior definition of captive alpine female musk deer

Behavior	Description
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 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 and self-scratching, etc
Affinitive Interaction (AI)	Direct physical contact between adult animals without obvious aggression, i.e., mutual grooming, sniffing and 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 and copulation and homosexual behaviors, etc.

of observations. The duration of each behavior was calculated in seconds with seasonal averages (±SE) compared for each animals and BP and FP females. Behaviors were standardized by individual and number of samples, respectively. Due to the infrequency and variable nature, Miscellaneous Behaviors (MB) were excluded from analysis. As females were housed together during whole study period and thus behavioral data were not independent therefore, the Wilcoxon Signed Rank test was utilized to explore behavioral differences BP and FP females. Statistic analysis was conducted with the SPSS 11.0 (SPSS Inc., Chicago, Illinois), using 2 tailed probability with a significance level of p = 0.05.

RESULTS AND DISCUSSION

Behavioral comparison between BP and FP female musk deer during non-mating season: As showed in Fig. 1, FP females demonstrated more resting behavior (54.70±19.59 sec) than BF musk deer (28.67±28.67 sec) and the latter showed more vigilance (132.78±51.41 sec) and locomotor behavior (36.92±21.57 sec) than the former (SA, 84.28±19.13 sec; LO, 21.76±4.89 sec) all these differences however were not significant ($p>0.05$). The duration of self-directed behavior (17.82±16.74 sec) in BP was high significantly more than that of FP (0.98±0.35 sec) ($p<0.01$). Both BP and FP females did not perform the tail-pasting behavior during non-mating season. The differences of the rest of behaviors were not significant ($p>0.05$).

Behavioral comparison between BP and FP female musk deer during mating season: The behavioral differences between BP and FP females during mating season showed in Fig. 2. FP musk deer expressed locomotor behavior (32.07±6.44 sec) environmental sniffing (31.89±11.75 sec) and agonistic interaction (1.52±0.63 sec) significantly more than BP deer (LO, 18.30±9.36 sec, $p<0.05$; ES, 3.41±1.14 sec, $p<0.05$; CI, 0.99±0.26 sec, $p<0.05$). The rest of behavioral differences was insignificant ($p>0.05$).

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. Stolba *et al.* (1983) suggested that to certain extent, the self-directed behaviors of captive animal could be considered as abnormal in behavioral analyzing as these behaviors does not direct other individuals but to itself. The data showed that FP females expressed less abnormal behavior than BP female which was agreement with Mallapur *et al.* (2006) findings namely the levels of abnormal behavior exhibited by captive lion-tailed macaques (*Macaca silenus*) was found to be related to their ability to breed and proven breeders exhibits significantly less abnormal behavior.

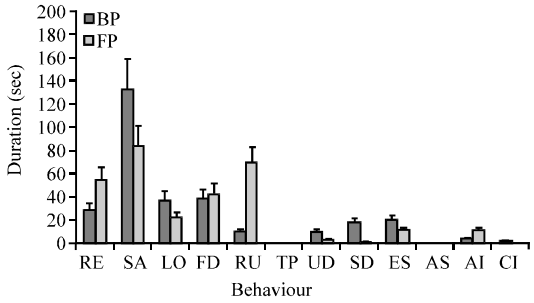

Fig. 1: Behavioral comparison between BP and FP female musk deer during non-mating season; BP: Females barren in previous year; FP: BP: Females fawning in previous year, behaviors include: Resting (RE), Vigilance (SA), Locomotion (LO), Feeding (FD), Ruminating (RU), Tail-Pasting (TP), Urinating-Defecating (UD), Self-Directed behavior (SD), Environmental Sniffing (ES), Ano-genital Sniffing (AS), Affinitive Interaction (AI), Agonistic Interaction (CI)

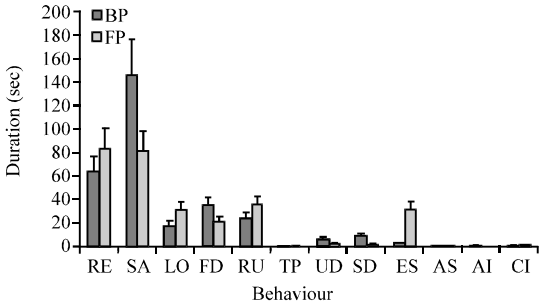

Fig. 2: Behavioral comparison between BP and FP female musk deer during mating season; BP: Females barren in previous year; FP: BP: Females fawning in previous year, behaviors include: Resting (RE), Vigilance (SA), Locomotion (LO), Feeding (FD), Ruminating (RU), Tail-Pasting (TP), Urinating-Defecating (UD), Self-Directed behavior (SD), Environmental Sniffing (ES), Ano-genital Sniffing (AS), Affinitive Interaction (AI), Agonistic Interaction (CI)

Zhang (1979) and Meng *et al.* (2003a, b) reported that when the mating season progresses, captive musk deer including females may become more active in its general behavior and females may actively moving and attempt to stay in the vicinity of the males. Generally, animal in rut shows increased activity and movement in open areas which associates with higher reproductive effort (Cushing, 1985). The current study showed that FP females expressed more loocomotor behavior in mating season which indicated that FP female was more active

than BP females at least during mating season. The data thereby suggested that FP females demonstrated more natural active pattern of normal female musk deer namely, FP female increased reproductive effort in rut season, BP female however was more sedentary. Musk deer is solitary and territorial and inhabits shrub-covered slopes in the sub-alpine zones of mountain regions thus the olfactory signaling between individuals is highly developed and scent is the musk deer's key means of communication and the dropping and urine are used as important scent marks (Sokolov, 1984; Green, 1987).

Wild musk deer may be moving about and depositing scent to advertise their reproductive status and attract a mate as has been observed in alpine musk deer and forest musk deer (*Moschus bererovzkii*) (Sheng and Ohtaishi, 1993; Green, 1987). In captivity, musk deer repeatedly defecate at special sites or latrines in enclosure meanwhile, cover its pellets with hooves which have interdigital glands (Sokolov, 1984).

The scent marking and information collecting are seasonal and the peaks distribute at the height of the mating season (Green, 1987; Zhang, 1979). Therefore, the captive environment abound in scent cues which could be detected by musk deer through environment sniffing to collect information on the identification whereabouts and the reproductive condition of musk deer.

Wu and Wang (2006) reported that the information collecting behaviors such as environment sniffing and ano-genital sniffing are common in captive musk deer especially during mating season. At XMDF, captive musk deer mark scent at special sites through urination, defecation, tail-pasting and pellet-covering and captive female musk deer constantly moves about to collect information about environment and other individuals, especially in mating season (Meng, 2002). Sheng and Ohtaishi (1993) also reported that captive forest musk deer increases the information collection in mating season which was supported by present results which showed that compared to BP female, FP female musk deer increased the environment sniffing to strengthen the information collection. Just like wild counterpart, captive alpine musk deer at XMDF remain territorial and build up their own preferred location in enclosure which does not overlap with each other (Sheng and Ohtaishi, 1993). Therefore, musk deer more often compete for preferred location and food resources moreover, musk deer will respond to the grooming, licking and even ano-genital sniffing from other individuals.

These factors could function as behavior releaser and result in that female musk deer demonstrate agonistic interaction. The present data showed that the FP female musk deer demonstrated more agonistic behavior than BP female during mating season which indicated that female bred in previous year was more pugnacious and budget more time in agonistic interactions with other individuals.

CONCLUSION

This study supports the various musk deer studies that compared to female barren in previous year, female bred in previous year was more active, pugnacious, explorative in mating season and expressed less self-directed behavior in non-mating season, the undertaken mechanisms however should be studied more in detail. In musk deer farming practice, the behavioral differences between FP and BP female musk deer should be taken into account when enclosure population is built up and breeding plan is designed and females should be differentiated by its reproduction history and the females fawning in previous year should be separated from those barren in previous year.

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