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The Impact of Seasons on Behavioral Pattern of Endangered Alpine Musk Deer in Captivity

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Abstract.- The alpine musk deer (*Moschus sifanicus*) is endemic to China and presently endangered owing to over-harvesting for its valuable musk and habitat loss, and musk deer faming is an important measure to conserve the wild populations and utilize the musk sustainably. The behavior patterns of alpine musk deer, however, must be understood, and applied into faming practice, on the basis of which, an appropriate faming and managing system could be developed. The aim of this study was to record and compare the behavioral patterns of captive alpine musk deer, in order to investigate differences in activity patterns in relation to season and its underlying causes. From August 2006 to January 2007, the behavioral patterns of 19 adult male and 13 adult female captive alpine musk deer were observed at the Xinglongshan Musk Deer Farm (XMDF) of Xinglongshan National Nature Reserve, Gansu Province of China. The faecal animal sampling and all-occurrence recording were used to record behavioral frequencies, and the behavioral comparison was made to decide the impacts of season on behavioral patterns of captive alpine musk deer. The results showed that from pre-rut season (from August to October) to rut season (from November to January next year), both of male and female demonstrated increased locomotor, defaecating-urinating scent, tail-pasting, standing-alert, environment sniffing and agonistic behavior, but decreased feeding and ruminating, moreover, female elicited male specific tail-pasting behavior. The energetic requirement in special physiological phase and preparation for reproduction were emphasized as the causations for the changing activity budgets.

Key words: Captive alpine musk deer (*Moschus sifanicus*), behavioral frequency, behavioral comparison.

INTRODUCTION

Musk deer (*Moschus* spp.) are the source of musk, a highly valued ingredient of perfumes and of some Chinese traditional medicines, which is secreted only by adult males. Alpine musk deer (*Moschus sifanicus*) is endemic to China, and endangered owing to over-harvesting and habitat-loss. Presently, alpine musk deer has been listed into Appendix II 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.

To conserve the wild musk deer populations and utilize the musk sustainably, musk deer farming has been developed since 1958 in China, and the main farmed species were forest musk deer *Moschus berezovskii* and alpine musk deer. The breeding in captivity and the sustainable extraction of musk from the live male deer is now appreciated (Homes, 1999; Parry-Jones and Wu, 2001), nonetheless there are still many problems confronting musk deer farming, such as high mortality, low production of musk, and shortened life span for musk secretion, and these remain to be solved before sustainable utilization of musk deer resources can be achieved.

Alpine musk deer is sparsely distributed in the mountainous region of western China, where it inhabits coniferous forests and deciduous forests at an altitude of 3000~5000 m. Because of its cryptic and solitary nature and high vigilance, the behavioral ecology of the alpine musk deer remains poorly understood (Green, 1986, 1987). Alpine musk deer farming has provided the opportunity to study ecology and behavior of this animal.

In China, the management and breeding patterns of musk deer farming were decided on the assumption that the captive musk deer has been domesticated, and such factors as nutrition have been overwhelmingly emphasized, while the management system and the natural behavioral

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biology of the species have not been adequately taken into account. In fact, musk deer are a typical small solitary forest ruminant (SSFR), which are difficult to manage and breed on farms because of their solitary habits, territorial behavior and excitable nature (Green, 1987; Homes, 1999). In fact, the behavior is an important aspect of farming and domesticating, and an understanding of the basics of behavioral patterns can lead to management applications.

Therefore, it is very important for the successful farming to conduct extensive behavior studies on captive musk deer to decide the patterns of activity budget and the potential season effect, and to form a basis for appropriate farming and management. Thus the main aim of this study was to record and compare the behavioral patterns of captive alpine musk deer in order to investigate differences in activity patterns in relation to season.

MATERIALS AND METHODS

Animals, housing and management

This study was conducted at Xinglongshan Musk Deer Farm (XMDF) in Xinglongshan National Nature Reserve, Gansu Province of China. The farm was located at an elevation of 2000~2100m. The reserve has a continental mountain climate with short, cool summers and long, harsh winters. January is the coldest month with temperatures averaging 9ºC, and the temperature minimum is -28ºC. The warmest month is July, averaging 14ºC. Rainfall is mainly in July, August and September, with annual precipitation of 48~62.2 mm.

At XMDF, five individuals were kept in an enclosure which consisted of an exercise area measuring 10 × 10 m, and males and females were kept in separate groups. Five enclosures were lined up in a row separated by an iron-mesh fence to prevent contact between the inmates of neighboring enclosures, although they could hear and smell each other. Animals in one row of enclosures were maintained by a keeper and were fed twice a day, at dawn and dusk, mainly with fresh leaves (in summer and autumn) or dried leaves (in winter and spring) which were collected from the natural habitats of wild musk deer, and supplementary artificial food (mainly consisting of flour, wheat bran and some vegetables in season). The amount of food provided was held constant and water *ad libitum* was also provided.

The ethogram and the behavior sampling

On the basis of published behavior patterns of musk deer (Sheng, 1993; Zhang, 1979; Green, 1987; Meng *et al.*, 2003), preliminary behavior observation was conducted to establish the ethogram of the captive alpine musk deer as follows:

Resting (RE): animal is lying on the ground and in inactive and relaxed state. Standing-alert (SA): animal is still, alert and gazing at stimuli or potential stimuli. Locomotor (LO): animal is obviously moving without any accompanying behaviors. Feeding/Drinking, (FD): animal is feeding or drinking. Ruminating (RU): animal expresses typical behavioral series of rumination, namely re-vomiting, chewing, swallowing and so on. Tail rubbing (TRL): animal is rubbing its tail and scent-marking on the surface of the wall or doorframe. Urinating/Defecating (U/D): animal fully or partially exhibits a series of activities such as earth-scratching, urinating and pellet covering. Environmental sniffing (ES): animal explores the wall or ground with its nose. Ano-genital sniffing (AS): animal sniffs the ano-genital region of another musk deer, sometimes with licking. Self-directed behavior (SD): animal expresses activities directed to itself, including self-grooming with mouth, self-scratching and other self-directed behaviors. Affinitive interaction (AI): direct body-touching activities without obvious conflict occurred among individuals, including mutual grooming, nursing and licking. Agonistic interaction (CI): obvious agonistic behaviors with or without direct body touching. Miscellaneous behavior (MB): all other behaviors.

Data collection and statistical analysis

Since the main fawning season of alpine musk deer is from June to July, and the mating occurs from later November in XMDF (Meng *et al.*, 2003), thus the observing duration from August to October was referred to as the ‘pre-rut season’, and the ‘rut season’ was defined as duration from November to January next year. Behavioral

observations were distributed over all daylight hours, which were conducted with binoculars (10×42°). To measure behavioral pattern, a focal musk deer was selected randomly from a group and data were collected by observing focal animals for 5 minutes and continuously recording all occurrences. The behavioral frequency was recorded on data sheets. All observation was conducted by the same researcher.

A total of 32 captive alpine musk deer were studied, among which, 19 were adult male and 13 adult female, and all individuals are captive-born and had been kept at XMDF for at least 2 years prior to this study. The behavioral observing took place 3 days a week and lasted for 6 months, and we attempted to sample each individual once a week. The behavioral frequencies were computed for every observation, and some behavioral samples were excluded from the data analysis, which the sampling duration was less than 5 min. The Wilcoxon Signed Rank Test was utilized to explore the behavioral differences between pre-rut season and rut season. Statistic analysis was conducted with the SPSS11.0 (SPSS Inc., Chicago, Illinois). Means are followed by standard errors (SE), and all reported statistical probability is two-tailed at P =0.05.

RESULTS

The behavioral comparison of males between non-mating season and mating season

As showed in Figure 1, male musk deer expressed resting behavior significantly more frequently (1.04±0.66) in pre-rut season than in rut season (0.18±0.06) (P=0.006<0.01), and male expressed significantly less standing-gazing (1.27±0.17) and locomotor (0.69±0.15) than in rut season (SA, 3.57±0.65; LO, 2.53±0.53) (SA, P=0.001<0.01; LO: P=0.008<0.01). Moreover, male fed (0.64±0.26) and ruminated (0.28±0.17) in rut season less than in pre-rut season (FD, 0.77±0.19; RU, 0.41±0.17), but these differences were not significant (P>0.05). During rut season, male elicited more tail-pasting (0.43±0.19), urinating/ defecating (0.17±0.09), environment sniffing (1.45±0.40) and ano-genital sniffing (0.06±0.04) than in pre-rut season (TP, 0.10±0.05; UD, 0.07±0.03; ES, 0.44±0.09; AS, 0.02±0.008), however, only the difference of Environmental sniffing was significant (P=0.005<0.01). Furthermore, male expressed more affinitive interaction (0.04±0.01) and less agonistic behavior (0.04±0.01) in pre-rut season than rut season (AI, 0.01±0.01; CI, 0.99±0.35), but only the latter difference was significant (P= 0.001<0.01).

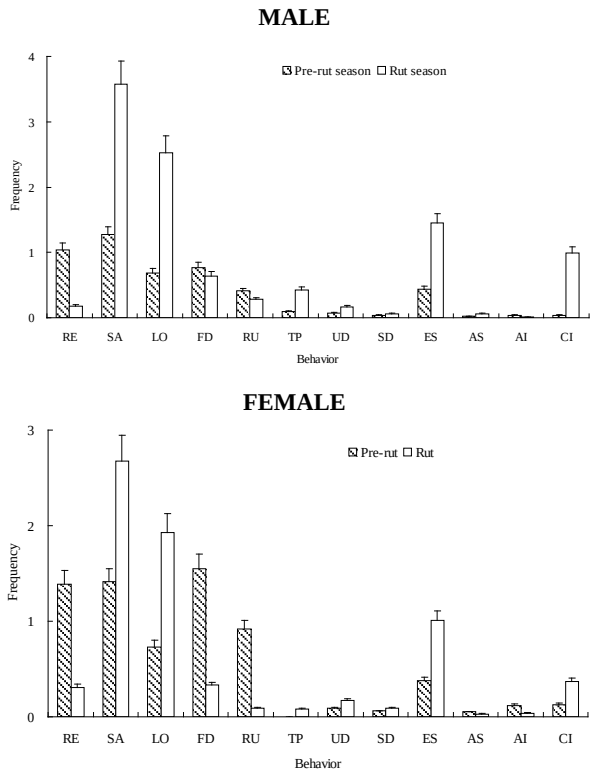

Fig. 1 The behavioral patterns of males and females between rut and pre-rut season.
RE, Resting; SA, Standing-alert; LO, Locomotion; FD, Feeding/Drinking; RU, Ruminating; TP, Tail pasting; UD, Urinating/Defecating; SD, Self-directed behavior; ES, Environmental sniffing; AS, Ano-genital sniffing; AI, Affinitive interaction; CI, Agonistic interaction.

The behavioral comparison of females between non-mating season and mating season

The behavioral comparison of females between rut and pre-rut season was showed in Figure 1. Female musk deer expressed resting behavior more frequently (1.39±0.88) in pre-rut

season than in rut season (0.31±0.07), however, the difference was insignificant (P=0.136>0.05). Female expressed significantly more standing-alert (2.68±0.39) and locomotor (1.93±0.36) in rut season than in pre-rut season (SA, 1.41±0.25; LO, 0.73±0.19) (SA, P=0.02<0.05; LO: P=0.01<0.05). Moreover, female fed (1.55±0.25) and ruminated (0.92±0.16) significantly more frequently in pre-rut season than in rut season (FD, 0.33±0.09; RU, 0.09±0.03) (FD, P<0.01; RU, P<0.01). Female elicited tail-pasting behavior in rut season (0.08±0.04), but no such behavior was expressed in pre-rut season, and the differences was significant (P=0.047<0.05). The urinating / defecating (0.17±0.06) and environment sniffing (1.01±0.28) in rut season were more frequently observed than those in pre-rut season (UD, 0.09±0.02; ES, 0.38±0.14), and the latter difference was significant (P=0.012<0.05). Furthermore, female expressed more affinitive interaction (0.12±0.05) and less agonistic behavior (0.13±0.08) in pre-rut season than those during rut season (AI, 0.04±0.03; CI, 0.37±0.09), but only the latter difference was significant (P= 0.014<0.05).

DISCUSSION

In evolutionary process, wildlife develops species and population specific behavioral modes to adapt to their environment. In order to adapt to special habitat, resource and climatic environment, wildlife could adjust their relation with the environment through behavioral adaptation. All life forms must consume resource and energy to maintain its life, and the activity patterns of animals could offer insight into how they allocate their energy through time (Relyea *et al.*, 1994). According to the resource allocation theory, time and energy budgeting of animal should bias to behavior related and reproduction during rut season in order to maximize the reproductive values and related evolution fitness. In captivity, animals have been protected and the environment of captive animals is different from the natural habitat, in which animal could not choose and change the environment factors, but the behavioral modes of captive animals could be changed at the specific extent to make the best response to the artificial environment. Schutz *et al.* (2001) suggested that the behaviors that have high energetic costs should decrease in domesticated animal breeds that are selected to invest a higher proportion of energy into production traits, and the captive animals under the same environment exhibit the similar behavioral mode because of the same (or similar) environment (Stolba, 1983). In this study, although the captive musk deer were be enclosed in different enclosure during pre-rut season, the facilities and managing system is identical, moreover, the female and male deer were enclosed into the same enclosure during mating season, therefore the influencing factor and intensity for female and male captive musk deer of XMDF were similar, furthermore, the captive musk deer have not been domesticated or tamed in this study (Meng *et al.*, 2006), which indicated that these captive musk deer have not been intentionally selected for special traits such as production, tameness and reproduction etc., thus the activity pattern and time budgeting of captive musk deer in this study should be similar to those of wild ancestors.

How much food an individual ruminant ingests per day depends on the time spent feeding, and the time available for feeding may limit an individual's daily forage intake and therefore affect its body condition, reproductive success and survival (Bruno and Lovari, 1989). In wildlife, the time allotted to feeding will vary depending on a number of factors, including feed availability, physiological process and season etc (Relyea *et al.*, 1994). The average daily time spent foraging of bighorns varies seasonally (Ruckstuhl *et al.*, 2003), and the adult male feral goats (*Capra hircus*) (Shi *et al.*, 2003) and the pronghorn antelope (*Antilocapra americana*) (Maher, 1991) sharply decreased the feeding time during rutting periods. Furthermore, more feeding and ruminating time during pre-rut, when female was in lactation, should partly be due to the high energetic requirements of lactation (Clutton-Brock *et al.*, 1982; Komers *et al.*, 1993). Increasing foraging time is the optimal strategy to compensate for higher energy demands, allowing lactating female musk deer recover from the energy loss. For wild *Ovis canadensis*, for example, an increase in feeding time during the pre-rut season may compensate for higher energy demands during

lactation and growth (Ruckstuhl *et al.*, 2003).

Wild musk deer has evolved unique behavioral characteristics which have contributed to their survival and proliferation in its special ecological environmental niche. In XMDF, captive male alpine musk deer secret musk in June and ripen in several months, and become sexually active from early November to late January next year, as for female musk deer, most of fawning occurred in early June and weaned by October, and come into estrus in late November (Zhang, 1979; Jiang, 1998; Meng *et al.*, 2003), therefore the male musk deer in this study were in post musk-secretion and the pro-estrus period during the defined "pre-rut season" (form August to October), but female were in lactating and pro-estrus, moreover, both of male and female musk deer were in estrous during defined "rut season" (from November to January). Because musk secretion is high energy consuming physiological process, during which the male deer becomes excited, refuses food and stops defecating, therefore male musk deer underwent energy and resource loss during musk secretion (Zhang, 1979). As for female, the functions such as gestation, fawning and lactating, are all energy consuming (Zhang, 1979), thus female and male musk deer at XMDF had strong energy requirement during pre-rut season. As suggested by this study, female and male musk deer elicited more resting, feeding, ruminating but less locomotor behavior during pre-rut season than during rut season. In agreement with this, the pronghorn antelope (*Antilocapra americana*) spent more time running and walking and less time feeding during rut season (Maher, 1991), and estrous female prairie deer mice (*Peromyscus maniculatus*) increased active time and elicited exploratory behavior to increase her chances of encountering a mate rather than just waiting for the male to detect her (Cushing, 1985), and the female and male desert mule deer (*Odocoileus hemionus*) increased activity from pre-rut to peak rut and to post-rut (Relyea, 1994).

In addition to satisfying its daily food requirements, ruminants in northern or mountain environments must accumulate enough fat during the growing season to reproduce and to survive the seasonal shortage of food during winter (Bruno and Lovari, 1989). Therefore, similar to feral goats (Shi *et al.*, 2003), male and female musk deer elicited more feeding and ruminating during pre-rut season than rut season, to accumulate energy to enter coming estrus. Meng *et al*. (2003) reported the similar result in captive alpine musk deer. In behavioral recording of the present study, we observed that, when rut season was coming, the male musk deer constantly moves from female to female to detect and chasing the estrous ones, whereas female in heat was restless and actively sought out and attempted to stay in the vicinity of the male, and female may sniff, lick or nuzzle the male during the peak of estrus in rut season. All these behavioral patterns were reported by other authors (Zhang, 1979; Jiang, 1998). Our results supported the mate searching hypothesis (Relyea *et al.*, 1994), namely musk deer increase the activity level in order to search for mate, and similar pattern was in *Peromyscus maniculatus* (Cushing, 1985).

Furthermore, while feeding, animals must also be vigilant to avoid predation. Vigilance is behavior that increases the probability that an animal will detect a given stimulus at a given time, which may serve to detect a variety of relevant stimuli, and its primary function appears to be the detection and avoidance of predators and potential disturbance. The resolution of the resulting trade-off between other behaviors and alertness should depend on the energetic requirements of the animal and the risk of predation it faces (Lima and Dill, 1990). The increased vigilance may therefore indicate decreased feeding (Ruckstuhl *et al.*, 2003). Alpine musk deer have a number of predators in natural environment, and rely on being inconspicuous to avoid predators (Zhang, 1979). The behavioral responses of the wild musk deer to the threat of predation are characterized predominantly by vigilance and flight, so individuals detect approaching danger in part through their standing-alert behavior (Green, 1986). In captivity, animal is kept in protected environment, and the daily artificial management act as the threat to captive musk deer, which was the same for both rut and pre-rut season. Furthermore, musk deer lead solitary lives, captive musk deer in this study, however, were kept in intensive faming system, which could increase the social density and social stress, added that the increased social interaction

such as mate-seeking and fighting for mate during rut season. Female and male musk deer increased the standing-alert and agonistic interaction from pre-rut season to rut season, which is supported by other reports (Zhang, 1979; Meng *et al.*, 2003).

Musk deer are very shy and solitary animals that may not become active until dusk, and inhabit steep, forested or shrub-covered slopes, mainly in the sub-alpine zones of mountain regions. Dense undergrowth of rhododendron, bamboo and other shrubs form the typical habitat, thus the olfactory signaling between musk deer is highly developed, and scent is the musk deer's key means of communication, and the droppings and urine are used as important scent marks (Sokolov, 1984). Green (1987) and Zhang (1979) reported that the defaecating/urinating mark is seasonal and the peaks in December at the height of the mating season. In agreement with this, the results of the present study suggested that both of female and male musk deer increased the defaecating/urinating and the related environment sniffing.

Tail-pasting is another scent making behavior of musk deer and has been defined as the male specific behavior (Green, 1987; Homes, 1999). The caudal gland of the male occurs as a thickening at the base of the short tail. It exudes a viscous yellow secretion, with an offensive odor. Typically, male musk deer rub the base of their tail throughout their home ranges, against the stems of bushes or dried herbs and grasses (Sokolov, 1984; Green, 1986). Our results, however, showed that the captive female alpine musk deer of XMDF did exhibit this behavioral pattern during rut season, and the sexual experienced females was more intended to paste at intervals of mating bouts, the behavioral mode, however, differed from the male's. When female elicited tail-pasting, it pasted its tail and ano-genital region against the projected objects such as the door frame of enclosure, and the duration was relatively shorter than male, however, the males demonstrated this behavior more intensively, and the obvious movement of up-down and left-right could be recognized clearly. Moreover, in this study, the duration and frequency of tail rubbing in female musk deer was less than those of males, and the tail rubbing of male deer during rut season was more intenser than pre-rut season, which was in agreement with other musk deer such as forest musk deer (Sheng, 1998), and indicated that male musk deer increased the scent marking intensity during rut through increasing the tail-pasting. The tail-pasting of male musk deer, however, could not be hitherto observed and reported, therefore this behavioral demonstration of female should be studied thoroughly to decide whether this is specific to alpine musk deer or an abnormal behavior developing in captive environment.

On the other hand, Zhang (1979) reported that musk deer will increases the information collection in mating season, which was supported by the results of the present study. Musk deer elicited more environment sniffing and ano-genital sniffing, and musk deer inclined to sniff, explore the enclosure, other individuals and even lick other musk deer on the hair and ano-genital region, where changes can be observed on the vaginal orifice at this time.

The breeding animals in captivity may lead to behavioral modifications, and domestication could change the release thresholds rather than add or eliminate behaviors in the animal's behavior repertoire, which could affect social behavior, fearfulness and aggressiveness of animals (Price, 1984). Hakansson (2007) suggested that social behaviors of animal may be more influenced by the social environment. Wild musk deer are essentially sedentary and territorial, accordingly musk deer occupied adjacent territories may come into contact with each other from time to time, and often engaged in border dispute (Green, 1987). In the artificial captive environment of XMDF, captive musk deer would be interacted and fight mutually more frequently because of the relatively narrow enclosure (100 m square), the lack of environmental richness and shelter, especially during rut, when individuals will fight for the potential mate. Thus in the present study, the female and male musk deer elicited more agonistic behaviour during rut season than pre-rut season, in agreement with this result, Zhang (1979) and Meng *et al.* (2003) found that musk deer are less placid and more pugnacious during rut season, compared to pre-rut season.

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