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Behavioral Aspects of Captive Alpine Musk Deer during Non-mating Season: Gender Differences and Monthly Patterns

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ABSTRACT : The objective of the present study was to determine gender-related and month-related behavioral differences in captive alpine musk deer. The study was conducted at Xinglongshan Musk Deer Farm (XMDF) of Xinglongshan National Nature Reserve in Gansu Province of western China. The integrated method of focal sampling and all occurrence recording was utilized to quantify the behavioural patterns of 45 captive alpine musk deer (*Moschus sifanicus*) during non-mating season (from August 1st to October 25th), and the behavioural durations of 12 behavioural patterns such as standing-gazing were recorded. The behavioural modes were compared to explore the potential differences between females and males, and the monthly behavioural modes for males and females were analyzed. Our results showed that the captive female deer in XMDF could compensate the energy lost in pregnancy, parturition and lactation through improving its ingestive efficiency. In order to be more sensitive to the changing environment, females expressed more standing-gazing (SG: 67.38±12.69 s) and moving (MO; 27.41±5.02 s), but less bedding (BE: 42.32±11.35 s) than male deer (SG: 56.43±9.19 s; MO: 19.23±4.64 s; BE: 96.14±15.71 s). Furthermore, females perform more affinitive interaction (AI: 7.89±4.81 s) but less ano-genital sniffing (AS: 0.24±0.13 s) and agonistic behaviour (CI: 0.57±0.26 s) than males (AI: 1.45±1.09 s; AS: 0.45±0.29 s; CI: 1.42±0.67 s). The females expressed ingestion more in October (132.31±27.47 s) than in August (28.80±18.44 s) and September (45.1±10.84 s), and the males performed Ano-genital sniffing (AS: 1.79±1.14 s) and self-directed behaviour (SD: 12.61±5.03 s) significantly more in October than in August (AS: 0 s; SD: 0.62±0.17 s) and September (AS: 0.02±0.01 s; SD: 0.17±0.15 s). Moreover, male musk deer increased the intension of ano-genital sniffing, agonistic behaviour and tail rubbing behaviour, which were related to sexual activities. (**Key Words :** In Captivity, Alpine musk deer (*Moschus sifanicus*), Non-mating Season, Behavioural Characteristics)

INTRODUCTION

Musk deer (*Moschus spp.*) are the source of musk, a highly valued ingredient of perfumes and of some Chinese traditional medicines. It is secreted only by the male, during the breeding season. Musk deer occur in at least 13 countries in South Asia, East Asia, Southeast Asia and the eastern parts of Russia; throughout their range they have become endangered because of habitat loss and hunting for musk from historic times (Homes, 1999; Yang et al., 2003). All musk deer species have been listed on the Appendices I and II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) since 1979.

Musk deer farming, which was initiated in China in 1958, is one of the most important measures to conserve and sustainably utilize musk deer resource (Meng et al., 2006). The main farmed species are forest musk deer (*Moschus berezovskii*) and alpine musk deer (*Moschus sifanicus*). There are about 2000 captive musk deer in China for sustainable extraction of musk from male deer (Homes, 1999; Parry-Jones and Wu, 2001; Meng et al., 2006); 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 (Xu and Xu, 2003; Zhou et al., 2004).

Musk deer farming in china has been established with the aim of extending domestication. Nutrition management has been overwhelmingly emphasized in captive breeding programs, however, the natural behavioural biology of the species has not been adequately considered. In fact, musk

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deer are a typical small solitary forest ruminant (SSFR), which are difficult to manage and breed on farms because of their solitary habits, territorial behaviour and excitable nature (Green, 1987a). It is important for successful musk deer farming to understand the gender differences and monthly behavioural patterns to form a basis for appropriate farming and management. Therefore, the objective of the present study was to determine gender-related and month-related behavioral differences in captive alpine musk deer.

MATERIALS AND METHODS

Animals and management

This study was conducted in Xinglongshan Musk Deer Farm (XMDF), at Xinglongshan National Natural Reserve of Gansu Province in northwest China. A total of 45 captive alpine musk deer was sampled including 23 females and 22 males. Details of geographic, climatic and animal management were reported in previous studies (Meng et al., 2003a, 2003b).

Our subjects were either wild-caught or first-generation captive-born. Five to seven female musk deer were kept in an enclosure which consisted of an outdoor yard measuring 10×10 m square adjoining seven brick cells, each measuring 2×2 m square and with the ceiling 2 m above the floor. Five to eight 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. Between the rows of enclosures, there was a building and an area wide enough to prevent communication among individuals in the two adjoining rows. 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. In this study, the males and females were kept in separate groups and the animals were individually identified by a numbered plastic ear tag.

The definition of behavioural patterns

On the basis of published behaviour patterns of musk deer (Green, 1987a, 1987b; Zhang, 1979; Sheng and Ohtaishi, 1993), preliminary behaviour observation was conducted to establish the ethogram of the captive alpine musk deer as follows:

Bedding (BE): Animal is lying on the ground and in inactive and relaxed state. Standing-gazing (SG): Animal is standing inactively and gazing at a stimulus. Moving (MO): Animal is obviously moving without any accompanying behaviour. Ingesting (IN): Animal is feeding or drinking. Ruminating (RU): Animal expresses the typical behavioural 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 marking (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 behaviour (SD): Animal expresses activities directed to itself (Castle et al., 1999), including self-grooming with mouth, self-scratching and other self-directed behaviours. Affinitive interaction (AI): Direct body-touching activities without obvious conflict occurred among individuals, including mutual grooming, nursing and licking. Agonistic interaction (CI): Obvious agonistic behaviours with or without direct body touching. Miscellaneous behaviour (MB): All other behaviours.

Data collection and statistical analysis

Since the main birth season is from June to July, and mating occurs from later November in XMDF (Jiang, 1998, Meng et al., 2003b), the non-mating season in this study was defined has being from August to October. The behaviour observing and sampling were conducted from August 1st to October 25th, 2001. During non-peak activity periods, musk deer were inclined to hide in the shelters of enclosures, which caused most behavioural sampling to fail, so behavioural observation and recording was conducted during peak activity periods, ie. 04:30-07:00 and 20:00-01:30 (Meng et al., 2002). The enclosure was illuminated by faint red light (20W) during nighttime. Several studies have shown that faint red light has little influence on the behaviour of ungulates (Bowyer, 1981; Komers, 1999). Each observation lasted 5 minutes for each individual, and each animal observed equally. The integrated methods of focal sampling, scan sampling and all-occurrence recording (Altman, 1974) were utilized. The time point of each behaviour was recorded on data sheets. The observer was hidden from the animals while the behavioural observation was conducted, and all observations were conducted by the same researcher.

Friedman-two-way ANOVA was employed respectively to determine whether certain behavioural durations differed between females and males from August to October. A Wilcoxon test was used to make pairwise comparisons among months to test for significance differences between groups. . Statistic analysis was conducted with SPSS11.0 (SPSS Inc., Chicago, Illinois). All reported statistical

Table 1. The behavioural patterns of musk deer during the non-mating season

Behaviour	Female	Male	Sig.
Bedding, BE	42.32±11.35	96.14±15.71	**
Standing-gazing, SG	67.38±12.69	56.43±9.19	ns
Moving, MO	27.41±5.00	19.23±4.64	ns
Ingesting, IN	52.37±10.05	57.59±11.20	ns
Ruminating, RU	77.25±15.25	44.95±10.50	ns
Tail rubbing, TR	-	1.39±0.89	
Urinating/defecating, UD	7.20±2.88	1.04±0.41	ns
Self-directed behaviour, SD	2.57±1.88	3.28±1.47	ns
Environmental sniffing, ES	14.48±4.83	15.46±4.38	ns
Ano-genital sniffing, AS	0.24±0.13	0.45±0.29	ns
Affinitive interaction, AI	7.89±4.81	1.45±1.09	ns
Agonistic interaction, CI	0.57±0.26	1.42±0.67	ns

Data showed as mean±SE. ** High significantly different ($p<0.01$); ns = No significant difference ($p>0.05$).

probabilities are two-tailed at $p = 0.05$.

RESULTS

Comparison of the general behavioural characteristics of female and male musk deer during non-mating season

The general behavioural patterns of female and male musk deer are shown in Table 1. During the non-mating season, males exhibited bedding behaviour significantly (96.14±15.71 s) more than females (42.32±11.35 s) ($p<0.01$) in every sampling period of 5 min, and females exhibited standing-gazing (67.38±12.69 s), moving (27.41±5.02 s) and affinitive interaction (7.89±4.81 s) not more than males (SG: 56.43±9.19 s; MO: 19.23±4.64 s; AI: 1.45±1.09 s) ($p>0.05$). Moreover, no significant differences of ingesting and ruminating existed between males (IN: 57.59±11.20 s; RU: 44.95±10.50 s) and females (IN: 52.37±10.05 s; RU: 77.25±15.25 s) ($p>0.05$).

In the non-mating season, tail rubbing by females was not seen, while males exhibited this behaviour (1.39±0.89 s) with a highly significant difference ($p<0.05$). Furthermore, the self-directed behaviour, environment sniffing, ano-genital sniffing and agonistic behaviour were inclined to be more in males (SD: 3.28±1.47 s; ES: 15.46±4.38 s; AS: 0.45±0.29 s; CI: 1.42±0.67 s) than in females (SD: 2.57±1.88 s; ES: 14.48±4.83 s; AS: 0.24±0.13 s; CI: 0.57±0.26 s), and the urinating-defecating was exhibited by females (7.20±2.88 s) relatively more than by males (1.04±0.41 s), but these differences were not significant (Mann-Whitney U Test, $p>0.05$).

The monthly behavioural pattern of female musk deer during non-mating season

Over the course of the non-mating season, from August to October, the duration of ingestion in females (August: 28.80±18.44 s; October: 132.31±27.47 s) increased

Table 2. Monthly behavioural patterns of females during the non-mating season

Behaviour	August	September	October	Sig.
Bedding, BE	6.95±6.95	52.00±14.34	18.75±18.75	ns
Standing-gazing, SG	96.41±51.52	66.53±14.05	37.06±18.80	ns
Moving, MO	66.70±20.56	21.90±4.49	16.88±7.41	ns
Ingesting, IN	28.80±18.44	45.16±10.84	132.31±27.47	*
Ruminating, RU	53.55±32.73	84.49±18.79	56.25±35.90	ns
Tail rubbing, TR	-	-	-	
Urinating/defecating, UD	9.28±7.17	7.86±3.59	0.11±0.05	ns
Self-directed behaviour, SD	0.52±0.52	3.31±2.48	0.10±0.10	ns
Environmental sniffing, ES	21.91±11.54	9.68±3.82	38.75±34.24	ns
Ano-genital sniffing, AS	0.00±0.00	0.31±0.18	0.00±0.00	ns
Affinitive interaction, AI	14.32±11.04	7.87±6.08	0.00±0.00	ns
Agonistic interaction, CI	1.36±1.36	0.51±0.26	0.00±0.00	ns

Data showed as mean±SE. * Significantly different ($p<0.01$). ns: No significant difference ($p>0.05$).

Table 3. Monthly behavioural patterns of males during the non-mating season

Behaviour	August	September	October	Sig.
Bedding, BE	160.29±51.90	72.03±15.96	102.50±30.55	ns
Standing-gazing, SG	67.52±29.80	61.03±11.73	37.06±13.33	ns
Moving, MO	31.21±12.68	13.62±3.82	23.01±13.94	ns
Ingesting, IN	16.19±9.60	69.48±17.50	62.04±16.46	ns
Ruminating, RU	19.86±14.70	55.06±16.38	40.90±15.93	ns
Tail rubbing, TR	0.95±0.95	0.35±0.21	4.15±3.56	ns
Urinating/defecating, UD	0.02±0.01	1.26±0.58	1.34±0.99	ns
Self-directed behaviour, SD	0.62±0.62	0.17±0.15	12.61±5.03	*
Environmental sniffing, ES	2.93±1.73	21.82±7.28	10.36±3.68	ns
Ano-genital sniffing, AS	0.02±0.01	0.02±0.01	1.79±1.14	*
Affinitive interaction, AI	0.43±0.43	1.92±1.90	1.16±0.77	ns
Agonistic interaction, CI	0.01±0.01	2.27±1.14	0.55±0.34	ns

Data showed as mean±SE. * Significantly different ($p<0.01$). ns = No significant difference ($p>0.05$).

significantly ($p<0.05$) (Table 2), but all other behavioural differences were nonsignificant ($p>0.05$). Pairwise comparison showed that the female ingested significantly more in October (132.31±27.47 s) than in September (45.1±10.84 s) and August (28.80±18.44 s) ($p<0.05$), but the difference between August and September was not significant ($p>0.05$) (Table 4).

The monthly behavioural pattern of male musk deer during the non-mating season

The behaviour of the male during non-mating season is shown in Table 3. Ano-genital sniffing (AS) and self-directed behaviour (SD) were significantly different among the three months ($p<0.05$), but in all other behavioural patterns the differences were not significant ($p>0.05$). Pairwise analysis showed that the males performed AS and SD significantly more in October (AS: 1.79±1.14 s; SD: 12.61±5.03 s) than in August (AS: 0 s; SD: 0.62±0.17 s) and September (AS: 0.02±0.01 s; SD: 0.17±0.15 s) ($p<0.05$), but the duration of these two behaviours were not significantly different between August and September ($p>0.05$) (Table 4).

DISCUSSION

Behavioural differences between female and male alpine musk deer in captivity

The behaviour patterns of animals may be influenced by their reproductive situation via impacts on time and energy budgeting (Sullivan, 1988; Hunter and Skinner, 1998). In XMDF, the fawning season of female captive alpine musk deer was from the early June to the end of July, musk secretion by males occurred mainly from early May to the end of July, the non-mating season (August to October) was the lactation period of females and the period of post musk secreting by males (Jiang, 1998; Mang et al., 2003b), hence the behavioural differences between the two sexes was related to their specific physical state.

Zhang (1979, 1983) and Sheng and Ohtaishi (1993) reported that, when the captive musk deer expresses standing-gazing behaviour, its ears are erect and moving about to collect environmental cues and it responds to potential stimuli such as strange noises and abruptly moving objects. In this research, we explored similar behavioural expression in XMDF, which implies that standing-gazing in captive alpine musk deer could reflect a form of heightened vigilance.

Generally speaking, the vigilance of an animal may be influenced by its reproductive situation (Sullivan, 1988; Hunter and Skinner, 1998). In this study, females were in the season of lactation and nursing (Jiang, 1998; Meng et al., 2003b), so females would notice, decide and follow any environmental stimulation and change, which would increase related energy and time budgeting. Once any environmental stimulation was decided, females would be inclined to cease relatively static behaviour such as bedding

Table 4. The pairwise comparison of key behaviours from August to October

Sex	Behaviour	Aug vs. Sep	Aug vs. Oct	Sept vs. Oct
Female	Ingesting, IN	ns	*	*
Male	Self-directed behaviour, SD	ns	*	*
	Ano-genital sniffing, AS	ns	*	*

* Significantly different ($p<0.05$). ns = No significant difference ($p>0.05$).

and ingesting to initiate such active behaviours as standing-gazing and moving, so that the duration of bedding and ingestion by females were lower than those of males, while the duration of standing-gazing and moving were longer. Furthermore, males were in post musk secretion in this research, a phase during which males will lessen their activity levels (Zhang, 1983; Sheng and Ohtaishi, 1993), consequently the males expressed more bedding and less standing-gazing than females.

The previous study has shown that, in gregarious mammals, females in the birth season will increase their energy intake through increasing feeding time and feeding efficiency to compensate for the energy lost in gestation, parturition and lactation, and so prepare for the coming reproduction season (Berger, 1992). In this study, female musk deer spent less time in feeding, but ruminated for longer than males, so we hypothesize that the captive musk deer female increases its energy intake mainly through the improvement of feeding efficiency. A more intensive study is required to test this, but a similar behavioural change was reported for captive forest musk deer (Du and Sheng, 1998).

Price (1984) defined domestication as a process by which a population of animals becomes adapted to humans and to the captive environment. By this definition, it is evident that captive musk deer can not be considered domesticated, but only as captive wildlife (see also Zhang, 1983). Furthermore, musk deer are a typical small solitary forest ruminant, the alpine musk deer being the most excitable species (Homes, 1999), with the males being more aggressive than females (Zhang, 1983). In the modern intensive farming system, the solitary musk deer is kept in groups in a relatively narrow enclosure (generally 4-6 musk deer in each 100 m^2), which causes more frequent mutual conflict. The females are more sociable than males, so agonistic behaviour between them is less frequent, and affinitive behaviour more so than males. Furthermore, the behavioural interaction between females and infants increases the expression of affinitive behavior.

Monthly behavioural patterns of captive musk deer

In XMDF, females were lactating and recovering energy during August and October (Meng et al., 2003b), and needed to increase their feeding intensity to compensate for the energy loss, and increased time and energy budgeting for lactation and nursing. Consequently, females rested least and gazed longest in August, after which the duration of standing-gazing and moving shortened progressively till October and only the feeding duration continued to increase. Because of this, the behaviour pattern of the female in August should be given special attention in farming practice and a relatively large and quiet captive environment should be provided to lessen unnecessary stimulation. If possible, each enclosure should contain only one pair of females and their infants to decrease behavioural disturbance from other adult individuals. Furthermore, the weaning and separation of young should be initiated before October to allow the females to budget enough time to ingest and recover from their energy loss and reserve enough energy for the coming cold winter and reproduction (Berger, 1992).

In this study, the male was at its end of the period of musk secretion in August, and the time allotted to feeding and ruminating increased from August to October. Our result is consistent with some reported observations which showed that the male in musk secretion will be more static, peaceful, and inclined to lie and reduce or even cease feeding (Zhang, 1983). The activity levels of wild ungulates increases when the mating season approaches (Berger, 1992), and the intensity of ano-genital sniffing, agonistic behaviour and tail rubbing, related to sexual activities, increased to a peak in October during the non-mating season.

CONCLUSIONS

During non-mating season, female musk deer did not exhibited tail rubbing behavior, and exhibited bedding behaviour significantly less than the males. From August to October, the females expressed ingestion in more October than in August and September, and the males performed Ano-genital sniffing and self-directed behaviour significantly more in October than in August and September.

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