Gender specific behavioural patterns of captive alpine musk deer (*Moschus sifanicus*)

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ABSTRACT. Alpine musk deer (*Moschus sifanicus*) have evolved behavioural characteristics which have contributed to their survival and proliferation in a unique environmental niche. Understanding these characteristics, specifically those relating to gender is vital in developing appropriate social and economic management systems for captive farming. This study compared the behavioural patterns of female and male captive musk deer to explore differences in gender. Thirty two adult captive musk deer, 19 males and 13 females, were observed from August 2002 to January 2003, at Xinglongshan Musk Deer Farm (XMDF) Gansu Province, China. The frequencies of 12 behavioural categories were recorded and compared between the two sexes. The results showed (1) that behavioural patterns were similar between female and male deer, (2) that female alpine musk deer can express male specific behaviour, such as tail-pasting and, (3) that gender differences in feeding and ruminating behaviour may be related to energy requirement and resource allocation patterns.

KEY WORDS : Alpine musk deer (*Moschus sifanicus*); Captivity; Behavioural patterns; Gender

INTRODUCTION

Musk deer (*Moschus* spp.) are 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 (ZHANG, 1979). Musk deer occur in at least 13 countries in South Asia, East Asia, Southeast Asia and eastern Russia, with populations currently in decline as a result of habitat loss and intensive illegal hunting for musk (HOMES, 1999). Alpine Musk Deer (*Moschus sifanicus*), an endemic species to the Qinghai-Xizang Plateau, Western China, is estimated at less than 100,000 individuals (SHENG & OHTAISHI, 1993) and is currently listed as vulnerable under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and protected as a Category I key species in China (SHENG & OHTAISHI, 1993).

Since 1958, captive farming has been conducted to conserve wild populations and sustainably utilize musk deer resources (HOMES, 1999; ZHANG, 1979). The predominantly farmed species include forest musk deer (*Moschus berezovskii*) and alpine musk deer (*Moschus sifanicus*), with captive populations in China of approximately 2000 individuals (HOMES, 1999; PARRY-JONES & WU, 2001). Successful captive breeding and the development of sustainable musk extraction methods from living deer has significant implications for the conservation and sustainable use of the existing wild musk-deer resources (ZHANG, 1979). In spite of husbandry advances, many problems including high mortality, low production of musk, and shortened life span, remain to be solved before sustainable utilization of musk deer resources can be achieved (HOMES, 1999; PARRY-JONES & WU, 2001).

In China, the management and breeding patterns of musk deer farming is based on the assumption that captive musk deer have been domesticated, and hence factors such as nutrition have been overwhelmingly emphasized, while natural behavioural characteristics 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 due to their solitary habits, territorial behaviour and excitable nature (GREEN, 1987).

The objective of the present study was to determine behavioural patterns of captive male and female musk deer, exploring these factors over reproductive seasons. Based upon this knowledge, an appropriate musk deer management system could be developed, in addition to providing a comparative data set for wild populations.

MATERIALS AND METHODS

Animals, housing and managing

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

A total of 32 captive adult alpine musk deer were studied at XMDF, including 19 male and 13 female ranging from two to seven years old. 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 10m×10m square with seven brick stalls, measuring 2mx2m with a height of 2m.

Five to eight enclosures were lined up in a row, separated by an iron-mesh fence which enabled olfactory and auditory communication between neighbouring inmates, but prevented physical contact. No communication was possible between rows. Animals were fed twice daily, at dawn and dusk, on a diet of fresh leaves (in summer and autumn) or dried leaves (in winter and spring) collected from the natural habitats of wild musk deer, and supplemented by artificial foods (consisting of flour, wheat bran and some vegetables in season). The amount of food provided was held constant and water was provided *ad libitum*.

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 enclosures, as with commercial breeding practices. All animals were individually identified by a numbered plastic ear tag.

Ethogram

On the basis of published behaviour patterns of musk deer (ZHANG, 1979; SHENG & OHTAISHI, 1993; GREEN, 1987), and preliminary observations, captive musk deer behaviour was characterized 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. Locomotion (LO): Animal is moving without any accompanying behaviours. Feeding/Drinking (FD): Animal is feeding or drinking. Ruminating (RU): Animal expresses typical behavioural series of rumination including regurgitating, chewing and swallowing. Tail-pasting (TP): 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 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 exhibits activities directed to itself, including self-grooming with mouth, self-scratching and other self-directed behaviours. Affinitive interaction (AI): Direct physical contact between individuals, without obvious conflict, such as mutual grooming, nursing and licking. Agonistic interaction (CI): Obvious aggressive behaviours with or without direct body contact. Miscellaneous behaviour, (MB): All other behaviours.

Data collection and statistical analysis

At XMDF, the main fawning season is from June to July (MENG et al., 2003a), with most mating occurring in late November (MENG et al., 2003b). Therefore observations made from August to October are referred to as the "pre-rut season", and from November to February as the "rut season".

Binoculars (10×42°) were used to observe behaviour and verify animal identification. A focal musk deer was randomly selected from a group. All occurrences of behaviour were recorded during a five minute period. All observations were conducted by the same researcher and took place three days a week for six months (total observation duration is 300 hours). Attempts were made to sample each individual once a week.

Behavioural frequencies, means and standard error (SE) were computed for every observation. Behaviour samples less than 5 minutes in duration were excluded from the data analysis. For statistical analyses, we used the average from all 5min observations as one data point for each individual per month. As female and male musk deer were housed in different enclosures during pre-rut season, and the behaviour of the two genders was not related, the Mann-Whitney U Test was used to test the potential differences between male and females in pre-rut season. During rut season, however, male and female musk deer were enclosed together, and as their behavioural modes were related the Wilcoxon Signed Rank Test was utilized. Statistical analysis was conducted using SPSS11.0 program (SPSS Inc., Chicago, Illinois) with a two tailed significance level of $P=0.05$.

RESULTS

Pre-rut season

The behavioural frequencies of male and female alpine musk deer during pre-rut season are shown in Fig. 1. Females were recorded resting (1.40±0.88) more frequently than males (1.04±0.66) ($P<0.01$). Similarly in females, frequencies of feeding/drinking (1.55±0.25) and ruminating (0.92±0.16) were significantly higher than in males (IN, 0.77±0.19; RU: 0.41±0.17; IN, $P<0.01$; RU: $P<0.01$). There was no significant difference ($P=0.064$) in the frequency of urinating and defecating (U/D) between females (0.09±0.02) and males (0.07±0.03). No tail pasting was observed for female deer during pre-rut season, whilst the male deer did exhibit this behaviour (0.10±0.05 occurrences).

Rut season

The distribution of behavioural patterns of captive musk deer during the rut season is shown in Fig. 2. The male deer rested (0.18±0.06) less frequently than the females (0.31±0.07), however, the difference was not significant ($P=0.44$). Males showed slightly higher frequencies of standing-gazing (3.57±0.65) and moving (2.53±0.53) than females (SG: 2.68±0.39; MO: 1.93±0.36), however no significant differences were found (SG, $P=0.250$; MO, $P=0.302$). Males fed (0.64±0.26) more frequently and ruminated less (0.28±0.18) than females (IN: 0.33±0.09; RU: 0.09±0.03), but only the difference in the former behaviour was significant (IN: $P=0.031<0.05$; RU $P=0.329>0.05$). During rut season, females were observed to exhibit tail-pasting, but its frequency (0.08±0.04) was significantly less than in males (0.43±0.19) ($P=0.002<0.01$). Furthermore, females showed less ano-genital sniffing and environment sniffing

(AS: 0.03±0.02; ES: 0.03±0.02) than males (AS: 1.45±0.40; ES: 0.03±0.02) though the differences were insignificant (AS: P=0.234; ES: P=0.329). Males exhibit agnostic interactions (0.99±0.35) significantly more frequently than females (0.37±0.10; P<0.05), whilst females expressed more affinitive interactions (AI: 0.04±0.03), however, these differences are not significant (P=0.287).

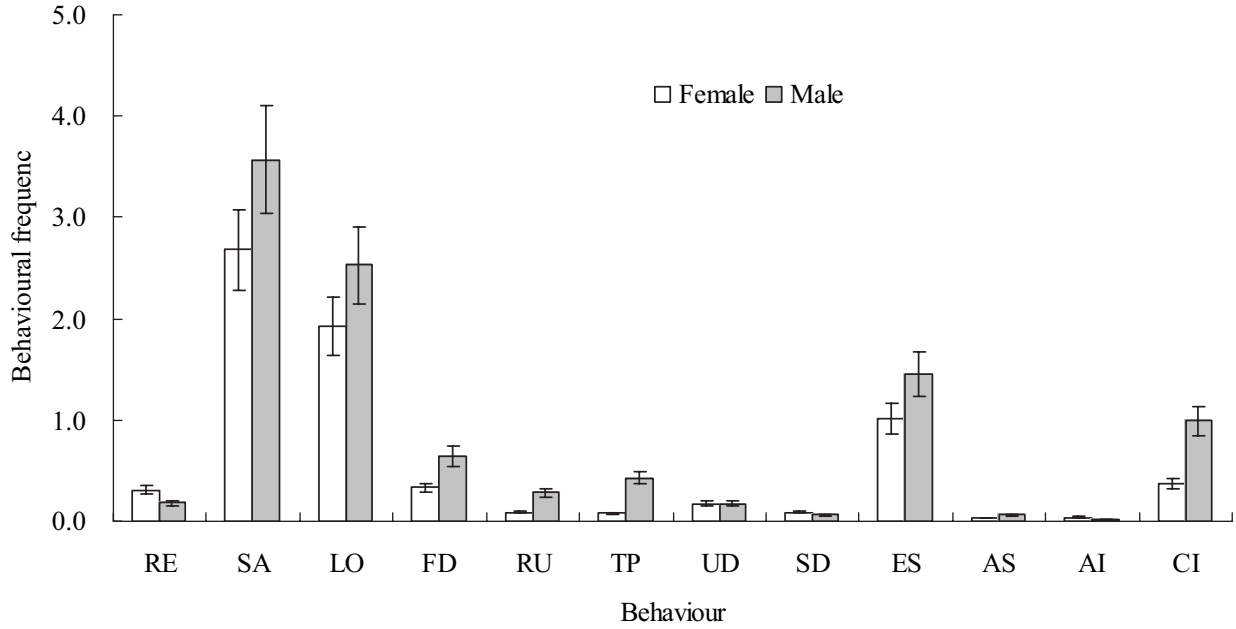

Fig. 1. – Frequency of female and male musk deer behaviour during pre-rut season.
(RE): Resting, (SA): Standing-alert, (LO): Locomotion, (FD): Feeding/Drinking, (RU): Ruminating, (TP): Tail pasting, (UD): Urinating/Defecating, (SD): Self-directed behaviour, (ES): Environmental sniffing, (AS): Ano-genital sniffing, (AI): Affinitive interaction, (CI): Agonistic interaction.

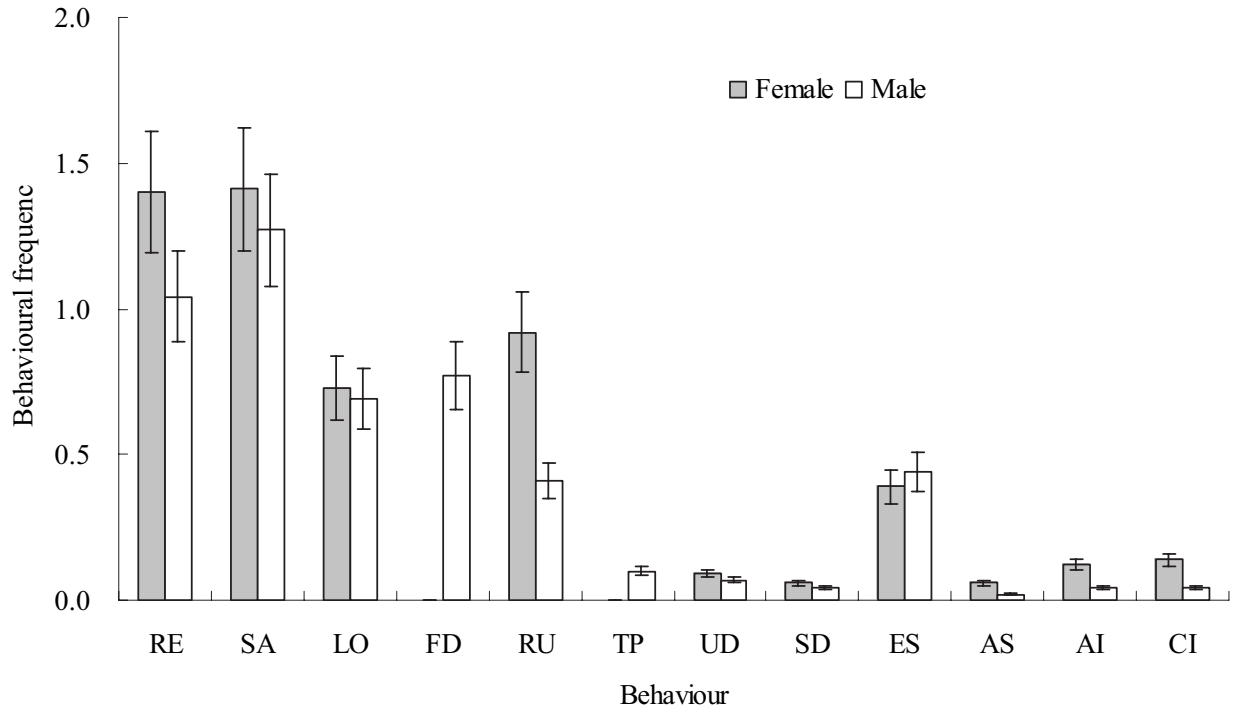

Fig. 2. – Frequency of female and male musk deer behaviour during rut season.
(RE): Resting, (SA): Standing-alert, (LO): Locomotion, (FD): Feeding/Drinking, (RU): Ruminating, (TP): Tail pasting, (UD): Urinating/Defecating, (SD): Self-directed behaviour, (ES): Environmental sniffing, (AS): Ano-genital sniffing, (AI): Affinitive interaction, (CI): Agonistic interaction.

Pooling rut and pre-rut

Pooled behavioural data, ignoring seasonal effects are shown in Table 1. Higher occurrence of resting in female musk deer (0.84±0.43) as compared to males (0.71±0.41) suggest that females rest significantly more than males (P=0.03<0.05).

TABLE 1

Comparison of the behavioural frequency between female and male musk deer

Behaviour patterns	Female (n=36)	Male (n=13)	Sig.
Resting, RE	0.84±0.43	0.71±0.41	*
Standing-alert, SA	2.06±0.24	2.15±0.31	ns
Locomotion, LO	1.35±0.22	1.40±0.25	ns
Feeding/Drinking, FD	0.93±0.15	0.72±0.15	ns
Ruminating, RU	0.49±0.09	0.36±0.13	ns
Tail-pasting, TP	0.04±0.02	0.23±0.08	**
Urinating/Defecating, UD	0.13±0.03	0.10±0.04	ns
Self-directed behaviour, SD	0.08±0.02	0.05±0.02	ns
Environmental sniffing, ES	0.71±0.16	0.83±0.17	ns
Ano-genital sniffing, AS	0.04±0.01	0.03±0.02	ns
Affinitive interaction, AI	0.08±0.03	0.02±0.01	ns
Agonistic interaction, CI	0.25±0.06	0.41±0.15	ns

Note: Data showed as mean ± S.E.; *: significantly different (P<0.05); **: highly significantly different (P<0.01); ns: no significant difference (P>0.05).

DISCUSSION

According to the resource allocation theory, animals allocate resources and energy in reproduction and growth in order to maximize their fitness (SCHUTZ et al., 2001). In captivity, this can be achieved through behavioural variation, to maximize survival in an environment vastly different from which the animal evolved. SCHULTZ et al. (2003) proposed that in domesticated animals the frequency of energetically costly behaviour is expected to decrease, particularly in breeds that are selected to invest a higher proportion of energy into reproductive traits. Whilst captive musk deer were found to have little degree of domestication (MENG et al., 2006), the identical environment in which both male and female were housed and managed at XMDF, may contribute to the generally similar behavioural frequencies recorded in this study. Still, similar behavioural patterns have also been recorded for wild ungulate populations. For example SHI et al. (2003) reported no significant differences in general activity budgets between adult male and female feral goats (*Capra hircus*).

Despite similar patterns of behaviour for males and females, behavioural frequency did vary seasonally. During the pre-rut season, females displayed more feeding, resting and ruminating, as has been reported for other ungulates (*Ovis canadensi*; PELLETIER et al., 2004). Various studies have investigated the role of sexual dimorphism in ungulates in regards to feeding. Based on ungulate species, PELLETIER et al. (2004), proposed that foraging time should be higher in females, proportional to the dimorphism in body size. Whilst our study supports this theory with female musk deer recorded a lower body mass (ZHANG, 1979; MENG et al., 2006), this trend was not consistent during the rut season, as males recorded significantly higher feeding rates.

The sexual differences in time spent foraging and ruminating, however, could partly be due to the lactation. In captive female musk deer lactation occurs during the pre-rut season (August to October) following annual weaning of young in October (MENG et al., 2003a). This process is an energetically costly activity. For example lactating female ibex (*Capra ibex nubiana*) consume approximately 50% more food per kg of body weight than adult males (GROSS et al., 1996). During this time females showed high feeding and ruminating frequencies to compensate for higher energy loss during fawning and lactating.

There is also a potential trade-off between foraging and vigilance (RUCKSTUHL et al., 2003). Vigilance is a behaviour that increases the probability that an animal will detect a given stimulus at a given time (DIMOND & LAZARUS, 1974). When a stimulus occurs, musk deer cease resting and elicit a standing-alert behaviour to avoid predation. Wild animals increase vigilance at the expense of feeding time in response to predation risk or threats from conspecifics. For example, RUCKSTUHL et al. (2003) recorded higher vigilance in lactating female *Ovis canadensis* as compared to males, in response to increased requirements to prevent predation on offspring. In the wild, musk deer are solitary and highly territorial, occupying a home range of 20-30ha (GREEN, 1987). In captivity, however, several musk deer are housed in a relatively small area (100m square), thus the potential threat from conspecifics, in addition to management practices and other human activities are greatly increased. We recorded a higher frequency of elicit stanging-alert behaviour in females musk deer as compared to males, concurring with findings for *Ovis canadensis* (RUCKSTUHL et al., 2003).

Male musk deer also have a number of seasonal reproductive requirements. During rut season, males compete for female mates and often engage in aggressive interactions (ZHANG, 1979; SHENG & OHTAISHI, 1993). Unlike wild conditions, in which male home ranges are mutually exclusive, captive farming directly increases the proximity of competing males, and accordingly the likelihood of agonistic interactions. These behaviours are translated in the higher frequency of agonistic interactions for males during the rut season, along with an increased frequency of feeding. Physiological requirements, such as musk production may also play a major role in behavioural patterns. The secretion of musk by adult males, which occurs annually in June and July (ZHANG, 1979; MENG et al., 2003a; b; ZHOU et al., 2004), is an energetically costly process. During this process male deer become excited, refuse food and cease defecating, as suggested by the significant decrease in feeding during the pre-rut season (August to October).

In solitary animals, such as musk deer, the development of complex olfactory signalling systems is common, with scent marking used as a primary means of communication. GREEN (1987) and SOKOLOV (1984), defined tail-pasting as a male specific scent marking behaviour. Our

results, however, showed captive female alpine musk deer at XMDF exhibit this behavioural pattern during the rut season. Preliminary observations indicated that sexually experienced females were more likely to exhibit this behaviour which in-between mating bouts. In contrast to males, females exhibited tail pasting for a shorter durations, and with less intensity. However, the obvious up-down and left-right movements could be readily identified as tail pasting. In this study, tail-pasting observations were infrequent, however trends follow those reported by SHENG & OHTAISHI (1993), who observed an increase in scent making by male forest musk deer (*Moschus bererovskii*) during the rut season (SHENG & OHTAISHI, 1993). Further investigation of both male and female tail-pasting is needed to determine the underlying mechanism of this behaviour, its specificity to musk deer species, and whether it is a redundant behavioural characteristic of captive individuals.

On the basis of these results, we conclude that captive male and female musk deer generally display similar behavioural patterns. Significant seasonal gender differences were recorded for feeding and ruminating behaviour, which are likely linked to energy and resource allocation patterns. Furthermore we recorded the expression of tail pasting behaviour by female musk deer.

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