Journal of Animal and Veterinary Advances 10 (10): 1265-1268, 2011
ISSN: 1680-5593

Impacts of Gender and Age on Behavioral Frequencies of Captive Musk Deer During Lactation

Guang Ma, Baocao Gong and Xiuxiang Meng
College of Life and Environment Sciences, Minzu University of China, 100081 Beijing, China

Abstract: Behavioral patterns of captive alpine musk deer were studied at Xinglongshan Musk Deer Farm (XMDF) in northwest China. Throughout the lactation season (August-October 2003), 13 behaviors categories were recorded for 30 female and 24 male alpine musk deer (*Moschus sifanicus*) to explore effects of gender and age-classes. Females had a higher frequency of resting, feeding, ruminating and affinitive behaviors than males, potentially due to the increased energy demands and influences of newborn fawns during lactation. Among females there was no effect of age-class on the behavioral patterns whereas, adult males displayed more frequent tail-pasting behavior and agonistic interaction than sub-adult males. The potential causative mechanisms for the behavioral differences were discussed.

Key words: Alpine musk deer (*Moschus sifanicus*), behavioral frequency, lactation season, gender, age-class, China

INTRODUCTION

Musk deer (*Moschus* sp.) are the source of musk, a highly valued ingredient of perfumes and some Chinese traditional medicines which is secreted only by adult males. Musk deer occur in at least 13 countries including Russia and Southern and Eastern Asia. Throughout their distribution, musk deer have become endangered due to habitat loss and historic hunting for musk (Homes, 1999; Yang *et al*., 2003). All musk deer species have been listed on Appendices 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 an important measure to conserve and sustainably utilize musk deer resources (Parry-Jones and Wu, 2001; Wu and Wang, 2006). In China, approximately 2000 musk deer are currently housed in captivity with alpine musk deer (*Moschus sifanicus*) being the predominate species (Meng *et al*., 2006). The sustainable extraction of musk from live male deer was realized at an early stage of farming, nonetheless many problems such as high mortality, low production of musk and shortened life span for musk secretion, remain to be solved before sustainable utilization of musk deer resources can be achieved (Homes, 1999; Parry-Jones and Wu, 2001). Captive management practices have largely focused on nutritional requirements with little consideration of the behavioral biology of the species. Hence, investigating these topics can provide a basis for future management practices to improve the success of captive deer farming in China. This study aims to determine behavioral patterns of captive male and female musk deer by exploring the potential effects of gender and age-classes. 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: This study was conducted in Xinglongshan Musk Deer Farm (XMDF), Xinglongshan National Nature Reserve (N: 103.83-104.17°; N: 35.63 -35.97 °) in northwest China. Located at 2000-3670 m 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 9 and -28°C, respectively.

The warmest month is July, averaging 14°C. Rainfall is mainly in July, August and September with annual precipitation of 48-62.2 mm. A total of 54 captive adult alpine musk deer were studied at XMDF, including 24 males (7 sub-adults; 17 adults) and 30 females (5 sub-adults; 25 adults). At 2 years of age, musk deer are able to reproduce and males begin to produce musk hence deer <2 year old were classified as sub-adults those ≥2 year old as adults.

All deer were born in captivity and were houses in gender specific outdoor enclosures (15×15 m) with up to

Corresponding Author: Xiuxiang Meng, College of Life and Environment Sciences, Minzu University of China, 100081 Beijing, China

5 individuals. Enclosures were separated by iron-mesh which enabled olfactory and audio interaction but prevented physical contact between individuals. Animals were fed twice daily, at dawn and dusk, on a diet of fresh leaves collected from the natural habitats outsides of the farm 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 however sub-adult and adult individuals of the same sex were enclosed together. All animals were individually identified by a numbered plastic ear tag.

Behavior and definition: On the basis of published behavior patterns of musk deer (Zhang, 1983; Sheng and Ohtaishi, 1993; Green, 1987a, b) and preliminary observations, captive musk deer behavior was characterized as follows:

- 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 leaves, artificial food 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 behavior by rubbing the base of the tail in circular movement on the surface of a wall or doorframe
- Urinating/Defecating (U/D): 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 sniff 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 and other self-directed behaviors
- 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 infrequently occurring behaviors including stereotypic behaviors

Data collection and statistical analysis: Binoculars (10×42°) were used to observe behaviors and verify animal identification. A focal musk deer was randomly selected from a group. The individual was then observed and behavior frequency was recorded continuously for 5 min after which a second deer was selected at random and the process repeated. If the sampled animal was unsighted for >30 sec, the sample was discarded and next animal was randomly chosen for observation. Attempts were made to sample each individual once a week and the number of behavioral observing for each animal was balanced. All observations were conducted by the same researcher and took place 3 days a week during the 2003 lactation season (August-October). A total of 147 h of observation data was collected during the 3 months. Average behavioral frequencies (+/- standard error) were computed for every observation. As female and male musk deer were housed separately during the sampling season, the Mann-Whitney U-test was used to test the potential differences between male and females.

However, sub-adult and adult individuals were enclosed together and as their behavioral was not independent, the Wilcoxon Signed Rank test was utilized to explore the effect of age-classes. All statistical analysis was conducted using SPSS11.0 (SPSS Inc., Chicago, Illinois) with a two tailed significance level of $p = 0.05$.

RESULTS

The behavioral comparison between females and males during lactation season: As showed in Table 1, female musk deer demonstrated resting (1.40±0.88), feeding (1.55±0.25), ruminating (0.92±0.17) and affinitive interaction (0.12±0.06) significantly more frequent than males (RE: 1.04±0.67, $p<0.01$; FD: 0.77±0.19, $p<0.01$; RU: 0.41±0.18, $p<0.01$; AI: 0.04±.02, $p<0.01$). As females did not demonstrate tail-pasting, the frequency of this behavior was significantly lower when compared to males (0.10±0.06, $p<0.01$). The differences in all other behaviors were insignificant ($p>0.05$).

The behavioral comparison between sub-adult and adult females during lactation season: The behavioral differences between sub-adult and adult female musk deer are shown in Table 2. All behavioral frequencies between the two groups were not significantly different ($p>0.05$).

The behavioral comparison between sub-adult and adult males during lactation season: In non-mating season, the adult males displayed tail-pasting behavior (0.11±0.06) significantly more frequently than sub-adult males (0.09±0.06; $p<0.01$) (Table 3). Likewise adult males also

Table 1: The behavioral comparison between females and males in lactation season

Behavior patterns	Females (N = 30)	Males (N = 24)	Sig.
Resting (RE)	1.40±0.88	1.04±0.670	**
Vigilance (SA)	1.41±0.25	1.27±0.180	NS
Locomotion (LO)	0.73±0.20	0.69±0.160	NS
Feeding (FD)	1.55±0.25	0.77±0.190	**
Ruminating (RU)	0.92±0.17	0.41±0.180	**
Tail-Pasting (TP)	0.00±0.00	0.10±0.060	**
Urinating-Defecating (UD)	0.09±0.02	0.07±0.003	NS
Self-Directed behavior (SD)	0.06±0.02	0.04±0.020	NS
Environmental Sniffing (ES)	0.39±0.15	0.44±0.090	NS
Ano-genital Sniffing (AS)	0.06±0.02	0.02±0.010	NS
Affinitive Interaction (AI)	0.12±0.06	0.04±0.020	**
Agonistic Interaction (CI)	0.14±0.08	0.04±0.010	NS

The statistical method was Mann-Whitney U-test and data was showed as Mean±SE; **: Highly significantly different ($p<0.01$); NS: No Significant difference ($p>0.05$)

Table 2: The behavioral comparison between sub-adult and adult females in lactation season

Behavior patterns	Sub-adult female (N = 5)	Adult female (N = 25)	Sig.
Resting (RE)	0.04±0.04	1.72±1.08	NS
Vigilance (SA)	1.45±0.39	1.40±0.30	NS
Locomotion (LO)	0.75±0.40	0.73±0.23	NS
Feeding (FD)	2.05±0.63	1.44±0.28	NS
Ruminating (RU)	0.86±0.29	0.93±0.19	NS
Tail-Pasting (TP)	-	-	-
Urinating-Defecating (UD)	0.12±0.06	0.09±0.02	NS
Self-Directed behavior (SD)	0.14±0.09	0.05±0.02	NS
Environmental Sniffing (ES)	0.15±0.08	0.44±0.18	NS
Ano-genital Sniffing (AS)	0.10±0.07	0.05±0.02	NS
Affinitive Interaction (AI)	0.10±0.07	0.12±0.07	NS
Agonistic Interaction (CI)	0.10±0.07	0.14±0.10	NS

The statistical method was Wilcoxon Signed Rank test and data was showed as Mean±SE; NS: No Significant difference ($p>0.05$)

Table 3: The behavioral comparison between sub-adult and adult males in non-mating season

Behavior patterns	Sub-adult (N = 7)	Adult (N = 17)	Sig.
Resting (RE)	0.40±0.10	1.13±0.77	NS
Vigilance (SA)	1.20±0.34	1.28±0.20	NS
Locomotion (LO)	0.75±0.27	0.69±0.18	NS
Feeding (FD)	0.90±0.56	0.75±0.21	NS
Ruminating (RU)	0.35±0.10	0.42±0.20	NS
Tail-pasting (TP)	0.09±0.06	0.11±0.06	**
Urinating-defecating (UD)	0.11±0.11	0.06±0.03	NS
Self-directed behavior (SD)	0.10±0.10	0.03±0.01	NS
Environmental sniffing (ES)	0.45±0.20	0.44±0.10	NS
Ano-genital sniffing, (AS)	0.05±0.05	0.01±0.01	NS
Affinitive interaction (AI)	0.05±0.05	0.03±0.02	NS
Agonistic interaction (CI)	0.02±0.01	0.05±0.02	*

The statistical method was Wilcoxon Signed Rank test and data was showed as Mean±SE; *: Significantly different ($p<0.05$); **: Highly significantly different ($p<0.01$); NS: No Significant difference ($p>0.05$)

expressed agonistic interaction (0.05±0.02) significantly more frequently than subadults (0.02±0.01; $p<0.05$). Other behaviors were not significantly different ($p>0.05$).

DISCUSSION

During this study (August-October), the majority of sampled females had recently undergone parturition and were in lactation. Gestation, reproduction and lactation are energetically expensive physiological processes in which animals must increase energy ingestion and store fat reserves to compensate for the high energy loss in these stages. As such alteration in related behaviors may occur as a means by which the animal can adapt (Ruckstuhl *et al*., 2003). Furthermore, ruminants in northern and mountainous environments must accumulate enough fat to prepare for the following reproduction season and to ensure for food shortages in the upcoming winter (Bruno and Lovari, 1989; Berger, 1992). The above behavioral adaptations and adjustments were found in such ungulates as the mountain sheep (*Ovis canadensis*) and the pronghorn antelope (*Antilocapra americana*) (Ruckstuhl *et al*., 2003; Maher, 1991).

In this study, animals were provided with consistent food provision however, the results indicated that females increased food ingestion by a higher frequencies of resource gathering behaviors such as feeding and rumination. In contrast energetically expensive behaviors such as agonistic interaction were reduced while resting rates increased. Aside from the direct acquisition of energy, lactation season is characterized by increased mother-fawn interactions, namely nursing of the newborn fawn by its mother in addition to high intensive behavioral interactions such as grooming and ano-genital licking between lactation female and fawn, whilst the frequency of suckling reduces as the fawn grows older (Du and Sheng, 1996), many other social interactions are likely to occur among lactating does, fawns, other group females and peer fawns (Meng *et al*., 2003).

These behavioral interactions in female groups directly resulted in an increase in affinitive behavior frequency and indirectly affected the rates of other behaviors such as resting and feeding. Comprehensively, compared to males, female musk deer demonstrated resting, feeding, ruminating and affinitive interaction more frequently. As adult and sub-adult female musk deer were housed in the same enclosure, the behaviorual frequencies are not independent and hence sub-adults are also under the influence of fawns as was found in Rocky Mountain bighorn sheep (*Ovis canadensis*) (Ruckstuhl, 1999). Therefore, it was not surprising that age-class had no significant effect on the behavioral patterns of female musk deer in current study. In males however, the differences of tail-pasting and agonistic interaction between sub-adult and adult males were significant. The caudal gland of the male occurs as a thickening at the base of the tail. It exudes a viscous yellow secretion with an offensive odor from pores either side of the tail. Typically, male musk deer demonstrate male-specific tail-pasting behavior in which they rub the

base of their tail against the stems of bushes, dried herbs or grasses in the wild to designate an individual's home range (Sokolov, 1984; Green, 1987a). The former study indicated that captive male musk deer demonstrated tail-pasting behavior within an enclosure for the purpose of scent marking (Meng *et al*., 2003). The present results showed that the captive females did not elicit the tail-pasting behavior whereas the sub-adult male musk deer displayed tail-pasting behavior less than adult male musk deer which was in agreement with other reports (Zhang, 1983; Sheng and Ohtaishi, 1993). Furthermore, the present data showed that the adult male musk deer demonstrated more agonistic behavior than sub-adult males which was agreement with other reports that the adult male was more pugnacious than sub-adult males (Zhang, 1983; Wu and Wang, 2006).

CONCLUSION

On the bases of the present results, researchers suggest the behavioral patterns of captive musk deer and factors of gender and age-class should be considered in managing system and facilities design in musk deer farming. Whilst the social stress of captive musk deer is still to be investigated, reducing the number of individuals in each enclosure would assist in reducing agnostic interactions and better replicate the natural solitary lifestyle and adult and sub-adult should be enclosed separately.

ACKNOWLEDGEMENTS

This research was supported by Nature Science Foundation of China (30970374, 30770286, 30811120554), Program for New Century Excellent Talents in University (NCET-08-0596).

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