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Preliminary Studies on the Behavioral Assessment of the Domestication Degree of Captive Alpine Musk Deer

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Abstract.- Musk deer (*Moschus* spp.) are endangered due to high incidence of illegal hunting for musk and extensive habitat degradation. Musk deer farming may be an important way to conserve musk deer populations and as a method for the sustainable utilization of musk deer resources, but no assessment has been conducted on the level of domestication and the domestication potential of this species. An understanding of the basic behavior patterns and of the process of adaptation to captive conditions, particularly over successive generations, is vital in developing appropriate captive husbandry techniques for musk deer. Therefore, the objective of this study was to compare the behavioral patterns between wild-caught (WC) and captive-born (CB) musk deer to assess the degree of domestication of captive alpine musk deer. Focal animal sampling was used to record the behaviors of wild-caught and captive-born adult alpine musk deer at the musk deer farm of Xinglongshan National Nature Reserve, Gansu Province of China. The results showed no significant difference between wild-caught and captive-born musk deer in terms of the behavior indicators, and hence, little evidence of behavioral domesticity in captive individuals. In this regard, intensive farming of musk deer must be considered an interim means of conservation, rather than a long-term plan for species protection and musk utilization.

Key words: Alpine musk deer (*Moschus sifanicus*), behavioral assessing, captive-born, domestication, wild-caught.

INTRODUCTION

Musk deer (*Moschus* spp.), well-known for the production of musk by adult male, are endangered across Asia as a result of loss of habitat and illegal hunting. All musk deer species are currently listed on the Convention on International Trade in Endangered Species (CITES, Appendix II) (Homes, 1999; Yang *et al*., 2003; Wang and Xia, 2004) and are protected under the Chinese State Key Protected Wildlife List as a Category I key species. Musk deer farming has been practicing since 1958 and has been considered an *ex-situ* protection option to conserve wild musk deer populations and utilize musk deer resources sustainably (Homes, 1999; Parry-Jones and Wu, 2001). However, the domestication degree of musk deer under farming has not been assessed.

Domestication has been defined as the process by which an animal population becomes adapted to human beings and to captive environments (Price, 1984). During domestication, animals adapt with respect to behavior and an array of other physiological or morphological traits, which give rise to a specific domestication phenotype (Price, 1998). In China, the common method of domestication of musk deer is intensive farming, in which many deer are housed in the same enclosure (Zhang, 1979). This environment is completely different from the natural habitat and so an evaluation of the effects of captivity on musk deer is important for successful breeding and musk production in the future.

Studies on the domestication and the related behavioral adaptations could provide a measure of domestication potential and can be used directly by the farming enterprise to improve captivity facilities and management of the musk deer. Furthermore, analysis of adaptive behavior patterns may offer further understanding of the relationship between behavior and farming production of captive musk deer. Most importantly, however, such basic behavioral information is needed about the processes of adaptation to captive conditions among non-domesticated individuals, in order to develop appropriate captive husbandry techniques for musk deer species.

Therefore, the objective of this study was to compare the behavioral patterns of wild-caught and captive-born alpine musk deer (*Moschus sifanicus*) in an intensive breeding system to assess the degree

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of domestication in captive alpine musk deer.

MATERIALS AND METHODS

Animals, housing and management

This study was conducted at Xinglongshan Musk Deer Farm (XMDF), in Xinglongshan National Nature Reserve of Gansu Province, northwest China. The farm is located at 2,000-2,100 m above sea level. The reserve has a continental mountain climate with average winter and summer temperatures of 9ºC, and 14ºC, respectively. Rainfall occurs mainly in July, August and September, with annual precipitation of 48-62.2 mm.

A total of 46 captive alpine musk deer were studied at XMDF. Among them, seventeen females and seventeen males were caught as wild fawns (1-2 months old) (Wild-caught, WC) and kept at XMDF for at least two years prior to this study. In addition, six females and six males were born, reared and housed in captivity for 10 generations (Captive-born, CB).

Individuals were housed in groups of three to five in outdoor yards (10 × 10 m^2) with open access provided to five adjoining indoor brick cells (2 × 2 m^2) for the bedding of animals. Enclosures were separated by an iron-mesh fence which enabled olfactory and auditory communication between animals in adjacent enclosures, but prevented physical contact. Animals were fed twice a day, at dawn and dusk, on a diet of fresh leaves (April to October) or dried leaves (November to March). Leaves of the preferred forage species, *Crataegus kansuensis* and *Acer tetramerum*, were collected from the Xinglongshan National Nature Reserve. The diet was supplemented with artificial feed containing approximately 40% corn, 25% wheat, and 25% beans, which was mixed at site. Seasonal vegetables were also provided opportunistically and water was provided *ad libitum*. In this study, males and females were kept in different enclosures. However, animals were not separated on the basis of background, *i.e.*, WC and CB. All animals were identified by numbered plastic ear tags.

The ethogram and the behavior sampling

Based on the literature on musk deer (Zhang, 1979; Green, 1987; Sheng and Ohtaishi, 1993), preliminary behavior observations were conducted to establish the ethogram of captive alpine musk deer at XMDF (Table I).

Table I.- **The ethogram and behavioral definition of captive alpine musk deer.**

Behavior	Definition
Resting (RE)	Animal is lying on the ground and in inactive or relaxed state.
Standing-alert (SA)	Animal is still, alert and gazing at stimuli or potential stimuli.
Locomotion (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, etc; regurgitating, chewing, swallowing
Tail-pasting (TP)	Animal is rubbing its tail and scent-marking on the surface of the wall or doorframe.
Urinating/Defecating (UD)	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.
Self-directed behavior (SD)	Animal expresses activities directed to it, including self-grooming with mouth, self-scratching and other self-directed behaviors.
Ano-genital sniffing (AS)	Animal sniffs or licks the ano-genital region of another musk deer, male to male and female to female.
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.

Data collection and statistical analyses

The behavior sampling was conducted from August to October 2005 at the musk deer farm of Xinglongshan National Nature Reserve, Gansu Province of China. Due to lighting restrictions, behavioral observations were recorded during daylight hours (05:00~08:00 and 17:00~20:00) with the assistance of binoculars to confirm individual ear tag numbers (Meng *et al.*, 2002).

To measure behavioral patterns, the focal sampling method was used (Altman, 1974) in which a focal musk deer was selected randomly from an enclosure group and its behavior was recorded continuously for five minutes before observing the next randomly selected deer, until all musk deer in one enclosure had been observed, then the individuals in next enclosure group were observed. In total, 46 individuals in 12 enclosures were studied.

The starting and ending time point of all occurrences of behavior were recorded during a five minute period using a stopwatch. All observations were conducted by the same researcher and took place three days a week for three months (total observation time is 120 hours). Each individual was sampled once a week. During the study, the animals' welfare was overseen by the Xinglongshan Musk Deer Farm, with no additional manipulation conducted aside from daily husbandry duties. No physical contact occurred during the study.

For statistical analyses, we used the average from all 5 minute observations as one data point for each individual per month. The duration of each behavior (seconds) was calculated by the recorded starting and ending time point, and the mean and standard error (SE) of durations were computed for every behavior. Behavior samples less than 5 minutes in duration were excluded from the data analysis. Behaviors were standardized by number of samples. Since WC and CB were not housed separately, and the behaviors of WC and CB musk deer were potentially related, the Wilcoxon Signed Rank Test was used to test the potential differences between WC and CB musk deer. However, male and female musk deer were enclosed separately, and since their behavioral modes were assumed to be not correlated, the Mann-Whitney U Test was utilized to explore the differences between female and male musk deer. Analysis was conducted using SPSS10.0 program (SPSS Inc., Chicago, Illinois, 1999) with a two-tailed significance level of $P = 0.05$ for all reported statistical probability.

RESULTS

Comparison of female and male musk deer

The resting of female (58.60±10.57 seconds) was significantly less than male (78.33±11.86 seconds) (Mann-Whitney U Test, P =0.042 < 0.05) Furthermore, females did not express the male specific tail-pasting behavior, so their tail-pasting duration (0 sec seconds) was significantly less than that of males (3.34±1.22 seconds) (Mann-Whitney U Test, P < 0.01). All other behavioral differences between female and male musk deer were not significant (Mann-Whitney U Test, P>0.05) (Fig.1).

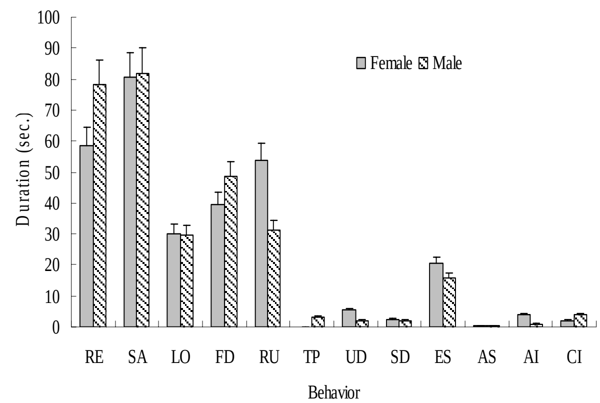

Fig. 1. The behavioral duration (+/- standard error) of female and male musk deer. (RE, resting; SA, standing-alert; LO, locomotor; FD, feeding/drinking; RU, ruminating; TP, tail-pasting; UD, urinating/defecating; SD, self-directed behavior; ES, environmental sniffing; AS, ano-genital sniffing; AI, affinitive interaction; CI, agonistic interaction.

Comparison of wild-caught and captive-born female musk deer

No significant differences (Wilcoxon Signed Rank Test, P > 0.05) were found between the WC and CB female musk deer for all recorded behavioral characteristics (Fig. 2), despite WC exhibiting more time to locomotion (33.40±5.38 seconds) than CB female musk deer (23.89±6.97 seconds) (Wilcoxon Signed Rank Test, P > 0.05).

Comparison of wild-caught and captive-bred male musk deer

Similar to female musk deer, no statistically significant differences (Wilcoxon Signed Rank Test, P > 0.05) were found between the behavior of WC and CB males (Fig. 3). WC males expressed more locomotion (31.79±6.14 seconds) and tail-pasting behavior (4.26±1.57 seconds) than CB (LO, 24.56±7.55 seconds; TP, 0.35±0.31 seconds) however, these differences were not significant (Wilcoxon Signed Rank Test, P > 0.05).

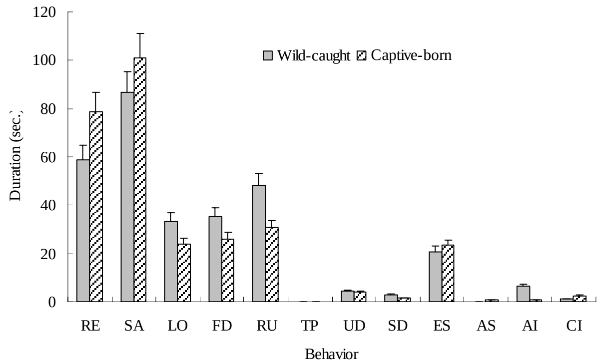

Fig. 2. The behavioral patterns of wild-caught and captive-born female musk deer. For other details see Figure 1.

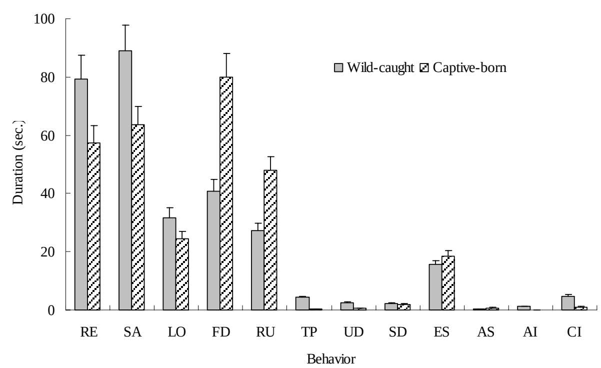

Fig. 3. The behavioral duration (+/- standard error) of wild-caught and captive-born male musk deer. For other details see Figure 1.

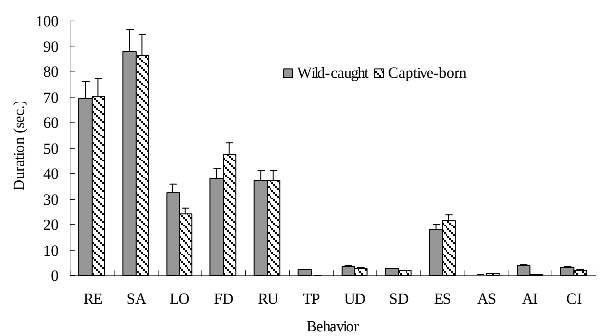

Fig. 4. The behavioral duration (+/- standard error) of wild-caught and captive-born musk deer. For other details see Figure 1.

Comparison of wild-caught and captive-born musk deer

There were no significant differences between WC and CB individuals (Wilcoxon Signed Rank Test, $P > 0.05$) (Fig. 4), although WC generally showed a higher incidence of locomotion (32.57±4.08 seconds) than CB deer (24.16±5.09 seconds), however no significant differences were found for any behavior categories (Wilcoxon Signed Rank Test, $P > 0.05$).

DISCUSSION

In their natural habitat, musk deer have evolved a unique array of behavioral characteristics which have contributed to their survival and proliferation in a specialized ecological niche. Wild musk deer are solitary animals and have exclusive and well-defined home ranges (Green, 1987), which make successful management and breeding in captivity difficult. Initial musk deer farms established in the 1950s in China recorded high mortality rates of wild-caught deer i.e., up to 60-70% of individuals dying from disease and poor husbandry (Homes, 1999).

Farming may lead to the development of captivity-based phenotypes, in which an animal’s behavior is changed to be adaptive to the environment, for example increased tameness or decrease in flight response distance to human activity. The main differences between wild and domestic animal species are due to different selection pressures and environmental constraints (Curio, 1996). The transfer of wild animals to captive environments by humans involves changes in resources, such as food, water and mating partners in addition to increasing the proximity of potential dangers such as humans and related artificial management. In this study, WC and CB musk deer were housed in identical enclosures, in which individuals had no control over the type and number of co-inhabitants, where there was no option to leave or modify the environment, and where resources such as food were limited and timed.

There is little evidence, however, to show that domestication results in the loss of specific behaviors, the addition of new behaviors, or the loss of adaptability to their environment. Andersen *et al.*

(2006) found that behavioral differences between wild and domestic stocks were best explained by differences in response thresholds. Animals in captivity are influenced by relaxed natural selection pressures, e.g., reduced predation, which can be considered as an early step in domestication (Håkansson *et al.*, 2007). In captivity, when animals are kept in close contact with humans, artificial selection may lead to a change from avoidance to accepting daily encounters with humans (Price, 1998). Nogueria *et al*. (2004) observed that the wild-caught capybaras (*Hydrochoerus hydrochaeris*) showed more flight response to humans than those bred in captivity. In agreement with this, Wu and Wang (2006) reported that when keepers were present in forest musk deer (*Moschus bererovskii*) enclosures, the behavior of wild-caught (WC) deer varied from captive-bred (CB) deer, with the former becoming increasingly agitated increasing running and movement within the enclosure. In this study, alpine musk deer were raised under a similar management system, in which keepers had daily contact with the deer at dawn and dusk, when feeding and husbandry duties occurred. However, the behavior sampling occurred during periods when the keepers were absent from the enclosure, and our results showed that there were no significant differences in general behavioral patterns between WC and CB musk deer. Further behavioral studies should be conducted to explore if WC alpine musk deer show greater flight responses to humans than CB deer. Alternatively, alpine and forest musk deer may adapt to the presence of humans differently. Zhang (1979) reported different levels of aggressiveness and tameness among musk deer species. This suggests that forest musk deer are more suited to domestication than alpine musk deer.

Modification of behavior is important to the adaptation of wildlife to a new environment, and this ability to change behavior may make the animal amenable to domestication (Mason, 1984). The degree of domestication of an animal, however, is difficult to estimate because an animal's phenotype depends not only on its genetic make-up but also on its experiences during ontogeny (Harri *et al.*, 2003), and the interaction of animals with their captive environment may result in differences within a given generation (Ricker *et al*., 1987). For example, Sara *et al.* (2001) found captive ocelots (*Leopardus pardalis*) to be less active than wild ocelots. In contrast, Bonacic *et al.* (2003) revealed that no discernible behavioral differences existed between wild-captured and captive-bred vicuna (*Vicugna vicugna*). Similarly, the current study found no significant behavioral differences between WC and CB alpine musk deer. As no discernable behavior pattern is evident in captive musk deer, even after ten generations in captivity, we can presume that musk deer at XMDF have not been domesticated, and the current method of farming is not appropriate for increasing the domestication of alpine musk deer. Furthermore, the farming could be considered a tool to conserve musk deer populations in the light of economic non-profitable nature of musk deer farms (Homes, 1999; Parry-Jones and Wu, 2001).

Domestication is a lengthy and gradual process. Domestically tame animals were developed through thousands of generations of human interaction (Mockin *et al.*, 2005). Domestication also involves biological changes with the stock being selected away from the wild type (Clutton-Brock, 1987). In all probability, domestic wildlife would not survive long in wild situations, and would be quickly destroyed if significant predator pressure were present. In China, musk deer (Alpine and Forest musk deer) which were born and raised in captivity have been recorded to survive for extended periods in the wild, following inadvertent release (Wu and Wang, 2006). This indicates that captive musk deer are not limited in responding in an adaptive manner to the natural environment and hence have not been thoroughly domesticated.

With the rapid loss of species worldwide, long-term maintenance of captive populations has become a common approach to species conservation. Long-term maintenance of captive populations followed by release of animals into the wild is one of many approaches to endangered species conservation. Such *ex situ* conservation, including captive breeding, however may lead to behavioral adaptation, affecting the success of reintroduction attempts (Håkansson *et al.*, 2007). McPhee (2003) reported that the longer generations of mouse (*Peromyscus polionotus)* have been in captivity, the less likely an individual was to take cover after seeing a predator, indicating that captivity can compromise animal behavior. The fact that alpine musk deer caught in the wild and raised in captivity do not behave any differently to those bred in captivity for several generations, and that those inadvertently released into the wild survive for extended periods, captive alpine musk deer could be re-introduced to the wild, and the released musk deer could survive in the wild (Wu and Wang, 2006).

Many factors can affect the domestication of animals, ranging from biological and ecological characteristics, to enclosure and managing systems. Domestication is a complicated process, involving the development of complex relationships with humans. It was reported that Forest musk deer adapt easily to captive condition based on normal feeding and reproduction soon after capture (Zhang, 1979). However the results of this study show that WC Alpine musk deer did not behave different from CB individuals after two years in captivity. Further studies are necessary to explore potential differences in physiological stress levels between wild-caught and captive-born animals, and among musk deer species, in order to develop appropriate environmental design and husbandry in captivity.

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