



## Development of Stereotypical Behaviour in Captive Fawns of Alpine Musk Deer *Moschus chrysogaster* Hodgson, 1839 (Artiodactyla: Moschidae)

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**Abstract:** Alpine musk deer is critically endangered and valuable animal. Adult male Alpine musk deer secrete musk, which can be used in traditional Chinese medicine and perfume industry. Alpine musk deer has been farmed for *ex-situ* conservation and sustainable musk provision. As Alpine musk deer is timid and solitary species, it is likely to develop stereotypical behaviour in captive environment. Stereotypical behaviour is unnatural and harmful behaviour performed by captive animals due to many factors, such as appetite and environmental constraint. In this study, the development of stereotypical behaviour was explored in captive Alpine musk deer fawns, which were all in lactation period (1-5 months of age). The stereotypical behaviours of fawns were observed and recorded by focal sampling and all-occurrence recording. The specific value of stereotypical behaviour time and sampling time of each fawn was used to show the change in each month of age and the results showed that, the fawns of 5 months old exhibited higher stereotypical behaviour than fawns that of 1 and 2 months old ( $P < 0.01$ ). Fawns displayed oral stereotypical behaviour (OSB, e.g., stereotypical licking) earlier than moving stereotypical behaviour (MSB, e.g., to-fro-walking), while the MSB was higher ( $0.080 \pm 0.028$ ,  $N = 19$ ) than OSB ( $0.034 \pm 0.012$ ,  $N = 28$ ) ( $P = 0.059$ ). In conclusion, stereotypical behaviour displayed in each month of age in captive Alpine musk deer fawns and this might be attributed to lactation, changes in feeding composition and environmental spatial constraints. This suggested that the lactation period was key for fawns to develop behaviour and necessary measures should be put in the conversation of musk deer fawns.

**Key words:** Alpine musk deer (*Moschus chrysogaster*), fawn, captivity, stereotypical behaviour, behaviour development

### Introduction

Stereotypical behaviour is non-functional, repetitive behaviour of animals in an unnatural environment (FRASER & BROOM 1997). There are many species of captive animals that exhibit stereotypi-

cal behaviour such as American black bears (*Ursus americanus*) (CARLSTEAD & SEIDENSTICKER 1991), Alpine musk deer (MENG et al. 2007), giant pandas (*Ailuropoda melanoleuca*) (DURNIN et al. 2004), Asian elephants (*Elephas maximus*) (ELZANOWSKI & SERGIEL 2006) and others.

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There are several hypotheses about the origin of stereotypical behaviour. One hypothesis is that stereotypical behaviour is caused by appetite. WECHSLER (1992) studied captive polar bears (*Ursus maritimus*) and found that the immobilization of appetite was manifested in stereotypical behaviour. In a study of captive Black Bears (*Ursus thibetanus*), CARLSTEAD & SEIDENSTICKER (1991) showed the peak of stereotypical behaviour throughout the day was before feeding or when animals were hungry.

A second hypothesis is that stereotypical behaviour is caused by environmental constraint. SAMBRAUS (1982) believed that tiny spaces and regular feeding could restrain animals' movement and foraging behaviour, thus leading to stereotypical behaviour. MASON (1991a) and BROOM (1991) deemed that the animal's lack of control over its environment and associated frustration, threat, fear and lack of stimulation could lead to the development of abnormal behaviour. WEBB et al. (2017) also proposed that the oral stereotypical behaviour in cows originated from genes affected by the environment. Other suggested causes of stereotypical behaviour are related to subspecies and birth history (BASHAW et al. 2001).

Natural and artificial stressors both influence captive animals in the environment. Natural abiotic environmental stimuli include suds, lights and odours, which a wild individual may actively avoid. Artificial restrictions include space restrictions, human's approach, a restriction on foraging and eating or abnormal population (MORGAN & TROMBORG 2007). Stereotypical behaviour may also be formed by animal self-organisation (FENTRESS 2010). It was found that stereotypies subserve a neurophysiological system whose function is to regulate level of arousal, as they require less processing capacity than the more complex and less often repeated patterns of behaviour; thus, some scholars have suggested that stereotypical behaviour may even be beneficial to animals (WECHSLER 1992). However, long-term observations are needed for more reliable explanations. For example, stereotypical behaviour may improve the sub-optimal environment in a longer period (MASON 1991a).

This study focused on the development of stereotypical behaviour in juveniles by sampling the behaviour of captive Alpine musk deer fawns at various ages in attempt to identify difference in behaviours. We aimed to explore the development of stereotypical behaviours and provide a guide for the research of stereotypical behaviour as well as *ex-situ* conservation of endangered Alpine musk deer.

## Materials and Methods

### Experimental animal and study area

Alpine musk deer is small and endangered ungulate; adult males secrete musk (ZHENG & PI 1979), which is a valuable commodity in traditional Chinese medicine and the perfume industry (DONG et al. 2001). As a result of habitat loss, wild Alpine musk deer populations have been decreased (YANG et al. 2003) to a population of less than 100,000 resulting into an endangered-listing on the IUCN Red List (IUCN 2018). Since 1950s, the *ex-situ* conservation of Alpine musk deer has been carried out in China (ZENG 2015). However, the lower survival rate (SHENG & LIU 2007) and the existence of stereotypical behaviour (MENG et al. 2007) of captive Alpine musk deer have persisted.

This study was conducted at the musk deer farm in Yuzhong County (104.12°E, 35.85°N), Lanzhou, Gansu Province of China (hereinafter referred to as the farm). The farm was located 2000~2100 m above sea level, with an average annual temperature of 6.7°C. Temperature difference between day and night is large and there are four distinct seasons. The farm included 15 feeding areas, each of which consisted of 4-5 side-by-side enclosures of approximately 100 m<sup>2</sup> area. The enclosures were separated by brick walls and wired-doors. Each enclosure was equipped with a 10×10 m activity field, a 2×3×2 m shelter, and 4-5 cells. The activity field was natural muddy slope. Vegetation included *Chenopodium* spp., *Artemisia* spp. and other herbs, as well as woody plants such as *Cupressus* spp. and *Sophora* spp. Keepers cleaned the colonies at 5:00 a.m. and feeding occurred at 17:00. Populations varied between September to October every year, with adjustment for male-female ratio in each enclosure and when fawns were weaned.

The behavioural sampling was carried out in two feeding areas, and 12 Alpine musk deer fawns were observed (7 males and 5 females, eight fawns born in 2017 and four fawns born in 2018), all fawns were nursed by their mother and fed by the same keeper.

### Behavioural sampling

Musk deer fawns were observed from June to August and September and October. During observation time, they were 1 to 3 months of age and 5 months of age. Fawns were surveyed with several 10 min sessions each day, one half of observations in morning (between 6:30 and 11:00), and the other half in afternoon (between 15:00 and 19:00). We classified summer activities of captive Alpine musk

deer according to the former study (MENG et al. 2002). Focal sampling and all-occurrence recording were used to record behaviour variables including behavioural frequency, behavioural duration and locus of behaviour of the fawns. Individual identification was carried out according to the external characteristics of the fawns, i.e. fur pattern, fur length and spots on body.

The stereotypical behaviours of Alpine musk deer fawns were classified into 5 classes (Table 1; see MENG et al. 2007). Stereotypical behaviours of captive Alpine musk deer fawns included stereotyped licking, platform-standing, wall-jumping, galloping and to-fro-walking. Stereotyped licking was oral stereotypical behaviour (OSB) and the other four stereotypical behaviours were moving stereotypical behaviour (MSB). In order to show the significance in stereotypical behaviours, we only used the data that contained stereotypical behaviour in each day.

### Statistical analysis and presentation of data

Statistical analysis and calculations were done in SPSS 19.0. The frequency and duration of stereotypical behaviour was analysed and the proportion of stereotypical behaviour of each fawn was calculated. Due to the management of the farm, we could not carry out samples of each fawn per day. We pooled individuals at the same age (1, 2, 3 and 5 month of age). Age was obtained by subtracting the fawn's birth date from the sampling date.

We assessed normality using the Kolmogorov-Smirnov test, and the analysis of variance (ANOVA) was used to analyse the potential behavioural difference between age classes. We also used Pearson correlation analysis to analyse the correlation between the behavioural variables and the stereotypical behaviours. For non-normally distributed data, we used Kruskal-Wallis test, Mann-Whitney test and Spearman correlation to analyse the data.

**Table 1.** Stereotypical behaviours of captive Alpine musk deer fawns

Behaviour	Behaviour describe
Stereotyped licking, SBL	Fawns lick wall or door, or eat non-edible objects (rocks).
Platform-standing, SBPS	Fawns stand for a long time on the shelter roof or the wall, gazing in a certain direction.
Wall-jumping, SBWJ	Fawns jump violently between the wall and the field (the jumping point and the landing place are usually fixed) until they are obviously tired and gasping.
Gallop, SBG	Fawns run fast in the field suddenly without obvious external stimulation, often making a circuit in the enclosure, sometimes accompanied by wall-jumping, until they are obviously tired and gasping.
To-fro-walking, SBTFW	The fawns walk back and forth by the door or wall without obvious stimulation. The turning point is fixed, and there is no other accompanying behaviour.

## Results

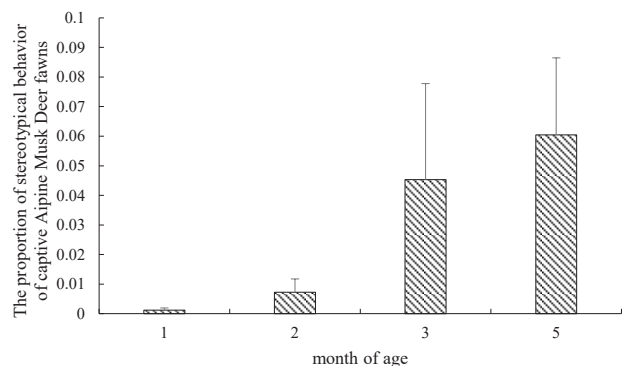
### Comparisons of stereotypic behavioural duration and frequency

The proportion of behavioural duration and frequency per behaviour were both non-normal distribution ( $P_{time} = 0.000 < 0.05$ ,  $P_{frequency} = 0.000 < 0.05$ ). The transformation by logarithmic and arcsine did not reduce the non-normality of the data ( $P < 0.05$ ). Spearman correlation showed that the frequency of stereotypical behaviour was significantly correlated with time ( $r = 0.988$ ,  $df = 128$ ,  $P = 0.000$ ).

### Change of stereotypical behaviour with age

Fawns began to show stereotypical behaviour at the age of 1 month (after 19 days), with an increasing trend with age (Fig. 1). The proportion of one-month-old fawns' stereotypical behaviour was  $0.001 \pm 0.001$  ( $N = 38$ ), with two-month-old was  $0.007 \pm 0.004$  ( $N = 52$ ). The proportion of 3-month-old and 5-month-old fawns' stereotypical behaviour time was  $0.041 \pm 0.030$  ( $N = 11$ ) and  $0.056 \pm 0.024$  ( $N = 27$ ).

There existed significant stereotypical behavioural difference among age classes (Kruskal-Wallis test,  $df = 4$ ,  $P = 0.000$ ). As showed in Table 2, stereotypical behaviour of 1-month-old was significantly different from that of 3-month-old ( $P = 0.047$ ) and



**Fig. 1.** Change of stereotypical behaviour over age. The error bars show SE.

**Table 2.** Independent sample Kruskal-Wallis test, multiple comparisons between months of age-paired comparison. \*  $P < 0.05$ ; \*\*  $P < 0.01$

Adjustment significance	1 month age	2 month age	3 month age	5 month age
1 month age		1.000	0.047*	0.000**
2 month age			0.089	0.000**
3 month age				0.802

5-month-old ( $P = 0.000$ ). Stereotypical behaviour of 2-month-old was significantly different from that of 5-month-old ( $P = 0.000$ ), while the stereotypical behaviour of other ages showed no significant difference.

**The proportion of stereotypical behaviours**

As showed in Fig. 2, wall-jumping was the behaviour found least frequently ( $0.019 \pm 0.018$ ,  $N = 2$ ), with to-fro-walking behaviour accounted for the largest proportion ( $0.126 \pm 0.091$ ,  $N = 2$ ). Stereotyped licking time accounted for  $0.034 \pm 0.012$  ( $N = 28$ ), galloping time accounted for  $0.034 \pm 0.009$  ( $N = 5$ ), and platform-standing time accounted for  $0.106 \pm 0.049$  ( $N = 10$ ).

The proportion of time spent on OSB was  $0.034 \pm 0.012$  ( $N = 28$ ), and MSB was  $0.080 \pm 0.028$  ( $N = 19$ ). The MSB was higher than OSB (Mann-Whitney Test,  $P = 0.059$ ,  $df = 2$ ,  $N = 47$ ).

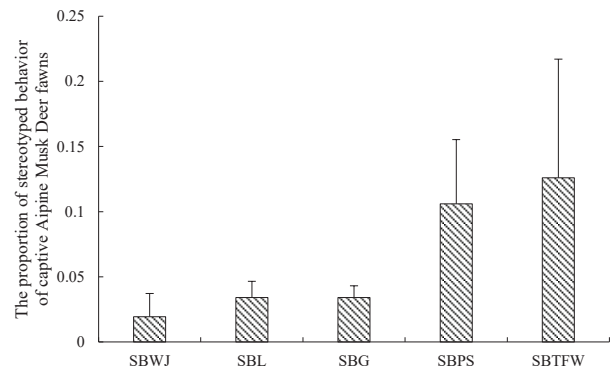
**Change of stereotypical behaviours with age**

The earliest recording of stereotypical behaviours of captive Alpine musk deer fawns were: 19 days of age (SBL), 54 days of age (SBPS), 125 days of age (SBG), 133 days of age (SBTFW), and 138 days of age (SBWJ). As shown in Figure 3, stereotyped licking was developed earliest and lasted for the longest time of stereotypical behaviours. Galloping, wall jumping and to-fro-walking appeared later but had certain synchronization.

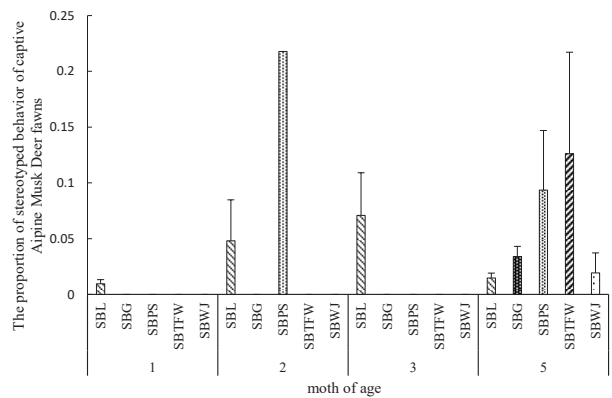
There was no significant difference in each stereotypical behaviour among months of age (Kruskal-Wallis test,  $P > 0.05$ ).

**Relevance of stereotypical behaviours**

There was significant correlation between to-fro-walking and platform-standing ( $r = 0.413$ ,  $df = 35$ ,  $P = 0.014$ ), and between wall-jumping and galloping ( $r = 0.788$ ,  $df = 35$ ,  $P = 0.000$ ). There was no significant correlation between other stereotypical behaviour ( $P > 0.05$ ) (Table 3). There was no significant correlation between OSB and MSB ( $r = 0.257$ ,  $df = 23$ ,  $P = 0.236$ ).



**Fig. 2.** The stereotypical behaviours. The error bars show SE.



**Fig. 3.** Change of stereotypical behaviours over time. The error bars show SE.

**Table 3.** Correlation analysis of stereotypical behaviours. \*Significant correlation at 0.05 level (bilateral). \*\*Significant correlation at 0.01 level (bilateral).

Stereotypical behaviours	SBL	SBPS	SBG	SBWJ	SBTFW
SBL	1	-0.142	-0.102	-0.062	-0.088
SBPS		1	-0.089	-0.049	0.413*
SBG			1	0.788**	-0.070
SBWJ				1	-0.035
SBTFW					1

**Discussion**

**Development of stereotypical behaviour in captive Alpine musk deer fawns**

Age might have a bearing on stereotypical behaviour. Whilst some studies showed that stereotypical behaviour in laboratory mice has no significant change with age (TILLY et al. 2010, BECHARD et al. 2012). Researchers showed that, however, the frequency of stereotypical behaviour had difference among age-groups (MENG et al. 2011, LEI et al. 2002). Mother-young contact, especially weaning,

could also have an impact on stereotypical behaviour. In a study of hogs (*Sus scrofa*), piglets were observed displaying stereotyped snout rubbing behaviour after separation from their mother (SHARMAN et al. 1982). In the process of re-mixing lambs and ewes after separation, oral stereotypes peaked on day 1 as did body-rubbing (LAMA et al. 2012). FOLEY (1934, 1935) found that social behaviour and sensory perception became monotonous after the separation of young monkeys from their mothers, which led to stereotypical behaviour. This study showed that captive Alpine musk deer fawns began to develop stereotypical behaviour at the age of 1 month, and stereotypical behaviour time increased with time.

REDBO (1992) found that heifers showed OSB at a higher level when tethered than housed in loose stalls. Studies on sheep by MARSDEN & WOOD-GASH (1986) showed that the single-bred sheep performed higher stereotypical behaviour than those group-bred. Therefore, the mode of captivity and whether the animals live in social environment had a certain impact on the stereotypical behaviour of captive animals. Alpine musk deer is solitary (FU 2010). In this study, the fawns performed sucking milk and mother-young contact with their mothers during their lactation period and lived independently after weaning time. With the increase of age, the fawns' demands for space increased, which led to conflicts with other individuals in the same enclosure. Especially when there were several fawns in one enclosure, the relative activity space of each fawn decreased with age. As a result, the time spent on stereotypical behaviour of the fawns increased with age. It could be seen that in captive animals, the intensity of stereotypical behaviour tends to increase with age, which is related to weaning and community changes.

Different stereotypical behaviours had different causes and effects on behavioural arousal and response by the animal (MASON 1991a). BASHAW et al. (2001) studied captive giraffes (*Giraffa camelopardalis*) and okapis (*Okapia johnstoni*) and found that the eating motivation was related to OSB, while other environmental factors such as sounds (MORGAN & TROMBORG 2007), were related to MSB, and one important pattern of giraffes' oral stereotypical behaviour was licking fences (TAROU et al. 2000). In this study, the OSB of captive Alpine musk deer fawns also included licking fences and brick walls. OSB appeared earlier than MSB in captive Alpine musk deer. The fawns mainly fed on breast milk before 1 month of age, and began to feed on grass or forage with obvious rumination after 1 month of age (LIN 2002). We assume that the fawns explore

non-breast milk food during the transition from pure breast milk to plant food. After 2 months of age, the musk deer fawns begin to wean (LIN 2002), meanwhile the forage fed from feeders gradually decreases (no fresh leaves in winter, and the fawns could only have forage) as winter approaches. During this time, the feeding disorders of fawns might aggravate the development of stereotypical behaviour. At 5 months of age when OSB decreases because fawns is weaned and gets nutrition from feeding on forage and leaves.

In this study, the MSB development of the fawns was later than OSB. Platform-standing was performed at 2 months of age, while the other three moving stereotypical behaviours of started at 5 months of age. The captive musk deer fawns spent most of their time lying in their first month of age (LIN 2002, DU & SHENG 1997), and then gradually increased their moving time. Therefore, the MSB didn't exist in the early stage. Meanwhile, during the study period the environmental temperature decreased with time. The increase of exercise time and the decrease of temperature may raise the feeding demands of the fawns. There was also an internal relationships between the OSB and MSB in fawns, which might be related to environmental changes and individual development. According to MASON (1991a), stereotypical behaviour elicited by one aspect of the environment may impact development enhanced by another. The effects of early captivity on the brain of young animals could lead to abnormal behaviour again in later development, and the intensity will exceed the early effects (MASON et al. 2007). In this study, we predict that during 1 month of age, the spatial restriction of environment had no obvious effect on the behaviour of the fawns owing to less demand for moving. After 1 month of age, the increase of demand for moving and feeding, and the restriction of captive space was prominent, which stimulated the development of MSB. Furthermore, there was a negative correlation between OSB and MSB. OSB decreased at the later stage of lactation (5 months old), while MSB increased gradually. This indicated that with the development and maturity of the fawns, musk deer developed more patterns of stereotypical behaviour in response to environmental stimuli.

In addition, fawns in one enclosure might also interact with those in other adjacent enclosures, which will result in the transmission effect of stereotypical behaviours. Studies showed that livestock may transmit information to their peers through special signals (NICOL 1996), which could affect their judgment of food. In this study, OSB of the fawns

relatively arose in one enclosure, while that in other enclosures were relatively low, which may be related to the transmission of stereotypical behaviour.

Therefore, the weaning period (2-5 months old) was the key period for the development of stereotypical behaviour in captive musk deer, and the development of OSB was earlier than MSB. There were many reasons for the development of stereotypical behaviour, such as weaning, changes in feeding composition and environmental spatial constraints. Individual interference in the same enclosure might also stimulate and strengthen the development of stereotypical behaviour.

### Harm and countermeasures of stereotypical behaviour

Stereotypical behaviours are harmful to animals as they can consume energy and damage nervous system health of animal. Researches showed that the energetic cost for stereotyped behaviour is considerable, and account for up to 8% (lying) and 15% (standing) of the energy expenditure for maintenance (BORNE et al. 2004). Studies by RIDLEY & BAKER (1982) showed that stereotypical behaviour was often accompanied by social isolation and cognitive impairment. On the other hand, stereotypical behaviour also affects offspring. LIEN & KLOPPER (1978) found that low stereotyped sow-fed animals made fewer errors than high stereotyped sow-reared animals. For captive Alpine musk deer fawns, the emergence of early stereotypical behaviour would consume valuable energy, and could be harmful to their physical development and social contact. Therefore, appropriate measures should be organized to reduce the frequency and time of stereotypical behaviour.

Some scholars had developed some quantitative methods for assessing whether stereotypical behaviour was within the normal range, such as using quantitative parameters (STOLBA et al. 1983) and developing a quantitative standard (BASSETT et al. 2003). However, researchers had not got a unified standard method to judge the intensity of stereotypical behaviour. This might be related to the great differences in species and captive environment. Therefore, measures should be taken to correct the stereotypical behaviour of the captive animals as long as it is observed.

There were two main ways to alleviate stereotypes. One way was to enrich the environment diversity, including facilities (increasing space complexity and adding toys, etc.) and feeding (multi-point feeding and intellectual feeding, etc.) (NOVAK et al. 1998, REES 2010). The former studies showed

that the complex environments and more time spent outdoors could bring more varied stimuli to captive animals to reduce the probability of developing stereotypical behaviour (BASHAW et al. 2001). The other way was drug therapy, such as serotonin-reuptake inhibitors, which might have side effects (MASON et al. 2007b). It is not recommended to use injections to captive Alpine musk deer fawns owing to their timidity, but might be investigated in cases where highly domesticated captive animals express severe stereotypes.

OSB of the fawns was related to the disturbance such as of human beings and other fawns in the same enclosure. Human activity is a huge factor to cause stereotypical behaviour of animal, and the fear of animals could interfere their behavioural learning (NICOL 1996). In the fawn and pups, the refined foods could reduce chewing consumption and facilitate the development of other behaviours in later stages (ENDO et al. 1994). Therefore, during weaning period, the forage should be cut into small pieces to ensure the feeding demand of the fawns.

The following measures are recommended reduce the development of stereotypical behaviour in captive Alpine musk deer fawns: (1) Increase food quality by ensuring fine forage and tender grass to feed fawns. (2) There should be more hiding spaces, trees and shrubs for fawns to hide and rest. (3) Provide sufficient space for each female Alpine musk deer and their fawns. (4) Assess stereotypical behaviour and change enclosure structure to alleviate the impact of stereotyped individuals on other normal fawns.

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