

# ASSESSING THE REACTIVE BEHAVIOURAL-PHYSIOLOGICAL CHARACTERISTICS OF CAPTIVE *MOSCHUS CHRYSOGASTER*: IMPLICATIONS FOR EX-SITU CONSERVATION AND CAPTIVE BREEDING

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Translocation, captive breeding and reintroduction to the wild are often used for the conservation of endangered animals. However, in captivity, wild animals may develop behavioural and physiological traits akin to domestication, such as reduced reactivity (similar to being more tame), which could have negative impacts on their reintroduction into the wild. This study was conducted from January 2021 to December 2023 at the Zhuanglang *Moschus chrysogaster* (hereinafter – musk deer) Breeding Farm in Gansu Province (China). The study recorded the intensity of reactive behaviour of 26 male musk deer, specifically their avoidance reactions to keeper and aggressive behaviour towards conspecifics. Faecal samples were also collected during the same period for the detection of cortisol metabolites. Principal component analysis was used to explore the behavioural and physiological characteristics of captive-bred musk deer in terms of reactivity. Based on these characteristic indicators, cluster analysis was conducted to assess the degree of reactivity of individual musk deer, dividing the 26 animals into high-reactivity and low-reactivity groups (i.e. more-tame vs. less-tame individuals). Subsequently, the study investigated the relationships between reactivity degree and age, musk secretion volume. The results showed that musk deer with a lower degree of reactivity exhibited reduced fear of humans and weaker aggressive behaviour towards conspecifics. Among 26 musk deer, five individuals were classified as the low-reactivity group, while others were in the high-reactivity group. The degree of reactivity was negatively correlated with age. There was no significant difference in musk secretion volume between the high-reactivity and low-reactivity groups (though the high-reactivity group showed a slight, non-significant decrease). Based on this study, it is recommended that musk deer farms construct different breeding environments for musk deer according to the breeding purposes. For musk deer intended for reintroduction to the wild, it is suggested to maintain their solitary living conditions and minimise human contact to preserve their wild nature.

**Key words:** behavioural adaptation, musk deer, musk secretion, reactivity-based management, reintroduction, stress physiology

## Introduction

Domestication is a continuous, multigenerational mutualistic relationship between the domesticator and the domesticated, in which one organism exerts a significant degree of influence over the reproduction and care of the other to ensure a predictable supply of beneficial resources (Terrell et al., 2003). Through this relationship, the partner organisms gain advantages over individuals outside this relationship, benefiting both the domesticator and the domesticated (Zeder, 2015). The process of increased domestication in wild animals involves changes in animal behaviour, physiology, and morphological structure (Larson & Fuller, 2014), such as reduced brain volume, degeneration of sensory organs, enhanced tameness, weakened aggressiveness, and decreased

activity of the Hypothalamic-Pituitary-Adrenal (HPA) (which regulates the secretion of cortisol, a hormone secreted in the stress response cascade and can be used to characterise the stress levels in animals (Sapolsky et al., 2000)) axis (Lord et al., 2020). Among these changes, behavioural alterations are considered to be at the forefront of the domestication process, primarily manifested in the shift from reactive behaviour (fear and aggression) to social behaviour (activity and affinity), which are associated with low reactivity of the HPA axis (Künzl & Sachser, 1999; Hare et al., 2012; Hansen Wheat et al., 2019).

Reintroduction programmes that rely on captive breeding and establishing a founder population are an effective strategy for *ex-situ* conservation (Ebenhard, 1995). However, cap-

tive breeding is analogous to the early stages of domestication, and the behavioural changes it induces may negatively impact reintroduction success (Kraaijeveld-Smit et al., 2006). For example, short-term captivity can weaken the migratory behaviour of *Salmo salar* Linnaeus, 1758, causing them to lose their way during oceanic migrations (Horreo et al., 2018). Similarly, captive environments can lead to abnormal expression of aggression in *Ameiva ameiva* Miller & Fitzsimons, 1971, which affects plans for reintroduction to the wild (Kelley et al., 2006). Therefore, for captive individuals destined for reintroduction, it is essential that their behaviour is minimally altered by captivity, meaning that their degree of wildness should remain high. As a result, for captive wildlife intended for reintroduction, regular behavioural monitoring and assessment should be conducted, and optimal husbandry practice should be established to maintain their wild nature.

*Moschus chrysogaster* (Hodgson 1839) (hereinafter – musk deer) is endemic to the Tibetan Plateau and surrounding areas of China. It is a small, forest-dwelling, solitary ruminant. The musk secreted by male musk deer is widely used in traditional medicine and the perfume industry. Due to historically illegal poaching for musk and habitat loss, wild musk deer have become critically endangered and is currently listed as a first-class protected animal in China (Meng et al., 2007b; Lu et al., 2025). Enhanced protection and *ex-situ* conservation based on captive breeding are the primary means of conserving this species. Captive breeding of musk deer began in China in the 1990s, with the aim of supporting the recovery of wild populations and achieving sustainable musk production (Zheng et al., 2022). However, wild musk deer are highly vigilant and solitary by nature, and the captive environment is vastly different from their natural habitat. It is still unknown whether this has altered their behavioural and physiological patterns.

Based on this, our study aimed to assess the reactive behavioural and physiological characteristics of individual musk deer by recording their avoidance behaviour towards human keeper and aggressive behaviour towards conspecifics, combined with the detection of faecal cortisol metabolites. The study also explored the relationships between degree of reactivity and age, as well as musk secretion volume.

## Material and Methods

### *Experimental site and subjects*

This study was conducted in the Zhuanglang Musk Deer Breeding Farm (ZMDB, 35.125544° N, 106.125605° E), Zhuanglang County, Gansu Province, China. The farm covers 0.1 km<sup>2</sup> and includes 150 units. The internal structure of each unit is essentially the same, including 5–8 small rooms, a 200 m<sup>2</sup> activity area and a shade shed. Each unit is surrounded by a fence made of wire to prevent the musk deer from escaping. The units are separated by brick walls and connected by wooden gates.

The study was conducted from January 2021 to December 2023, with 26 male musk deer from ten all-male units in the farm as the subjects (musk deer in all ten units were taken care of by the same keeper to avoid errors in the experiments caused by different keepers). The unit density (i.e. the number of musk deer in a single unit) was 2–4, including four units with a density of 2, four units with a density of 3, and two units with a density of 4. The ages ranged from two to six years old. All individuals were born and bred on the farm; none were wild-caught. Each musk deer is equipped with an ear tag for identification.

This study did not involve direct contact and manipulation of the musk deer, and efforts have been made to minimise the impact on them. The School of Ecology & Environment at the Renmin University of China and ZMDB reviewed and approved the protocols for the experiment before the animal research was initiated.

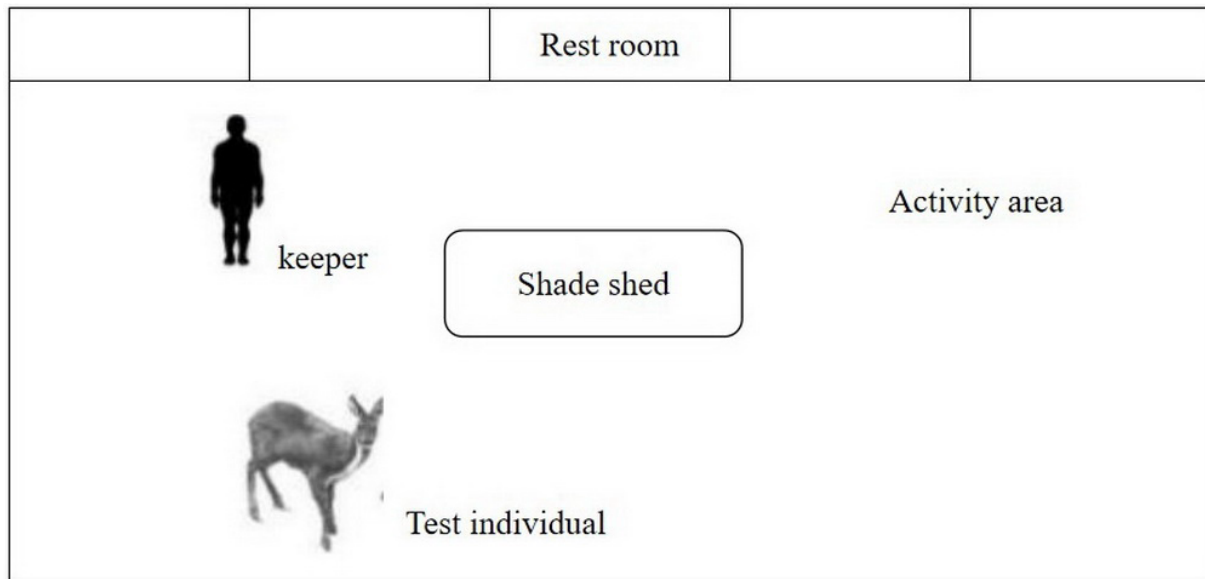
### *Human fear test*

Every morning at 5:00 h, the keeper enter the units to add feed and fresh leaves to each small room (Fig 1). Thirty minutes before the keeper enter the pens, video equipment was set up in advance outside the units at the fence. Ten minutes after the keeper finished the work in the target pens, the video equipment is removed for analysis and recording. Based on Huang et al. (2024), the time points at which musk deer exhibit alert reactions and the behaviour shifts from vigilance to escape; the order of escape; the mode of escape (Meng et al., 2007a); the time points when they escaped to a stable location, and the position of the stable location; the number of steps taken during escape were recorded through video. Variables were constructed based on the above for analysis (Table 1). The distances were measured by the keeper using a laser rangefinder to minimise the impact on the musk deer.

**Aggressive behaviour sampling**

Referring to the complete behavioural spectrum of captive musk deer (Meng et al., 2007a), behaviour sampling of the target musk deer was conducted during their peak activity periods (06:00–10:00 h; 16:00–20:00 h) (Meng et al., 2007a) to ensure the validity, comprehensiveness, and representativeness of the behaviour sampling. Binoculars and video recording were used to assist in observations. The frequency and duration

of the musk deer’s aggressive behaviour were recorded using focal sampling and specific behaviour recording methods (Meng et al., 2007a) (Table 2). Each behaviour sampling unit lasted for 10 min, and if sampling was interrupted within the unit due to external disturbances or the animal leaving the field of view, that record was not included in the calculation. A total of 130 effective behaviour samples were collected, which means a total of 1300 min of effective sampling time.



**Fig. 1.** Experiment set-up for the human fear test of captive musk deer. After entering units, the keeper moves in a straight line along the rest room, adds feed and fresh leaves outside the rest room of each musk deer, and then returns the same way without any direct contact with the musk deer.

**Table 1.** The variables and definitions in the human fear test of captive musk deer. Before the keeper entered the units, the musk deer individuals usually detected the abnormality by hearing footsteps and thus stopped their previous behaviour (e.g. feeding, resting) and shifted their gaze towards the direction of the keeper’s voice. The time interval from this reaction to the emergence of avoidance behaviour is defined as the alert duration

Variable	Definition
Alert duration	The duration from when the musk deer detects the keeper to when it exhibits avoidance behaviour
Escape order	a) First to escape; b) Subsequently escape; c) No escape
Escape mode	A) No escape; B) Stepping; C) Slowly walking; D) Jogging; E) Running
Escape duration	The time taken for the musk deer to escape from the start to the stable position
Escape steps	The total number of steps taken by the musk deer from the start of escape to the stable position
Stable distance	The straight-line distance between the musk deer’s stable position and the keeper

**Table 2.** The definition of aggressive behaviour in captive musk deer

Aggressive behaviour	Behaviour definition
Threatening	The individual stands with its neck erect and approaches the threatened individual.
Attacking	There is obvious physical contact aggression between individuals.
Displacement	An individual moves towards another to take its place, causing the latter to retreat.
Chasing	The sub-ordinate individual flees, while the dominant individual pursues and attacks.

### ***Cortisol hormone assay***

We used a non-invasive approach to measure the steroid hormones in musk deer during the behavioural sampling periods. When individual musk deer were observed excreting faeces, the faeces site and the ear-tag of musk deer were recorded, and the faecal samples were collected when the enclosure was entered for feeding at 17:00 h. Collected faeces were stored in self-sealing bags at -20°C for cryogenic storage.

Following the reported methods (Huang et al., 2024), radioimmunoassay (RIA) was used to determine cortisol hormone levels in faecal samples. Wet faeces were dried and ground followed by the addition of an alcohol solution, shaking, centrifugation, and drying in a water bath. A radioimmunoassay kit (Beijing North Institute of Biotechnology, China) was used to determine the cortisol hormone concentration. The concentration of cortisol metabolites in faecal samples is expressed in ng/g, that is, the number of ng of cortisol metabolites contained in each gram of faecal sample.

### ***Musk secretion volume***

In October 2023 (the musk harvesting season for musk deer), artificial musk extraction was carried out. After capturing and restraining the target musk deer, a medicine spoon was inserted into the musk gland sac to quickly scoop out the musk. The surface-attached moisture of the musk was absorbed with absorbent paper, and then the musk was weighed with a one-thousandth balance. This weight was taken as the musk secretion volume.

### ***Data analysis***

The various variables quantified from the human fear test, the total duration of aggressive behaviour from the observations (in this study, only displacement and threat behaviour were observed in musk deer), and the cortisol metabolite levels in faecal samples were standardised (Z-transformed) to normalise units (each variable scaled to mean 0, SD 1). Principal component analysis (PCA) was used to condense and reduce the dimensionality of the aforementioned data, and principal components (PCs) with eigenvalues > 1.0 were taken as explanatory variables. The hierarchical cluster analysis was performed on 26 musk deer based on the Z-transformed variables. A dendrogram was constructed using Ward method with Euclidean distance, and the 26 musk deer were divided into high-reactivity and low-reactivity groups. The Kolmogorov-Smirnov test was used to test

the normality of alert duration, escape duration, escape steps, stable distance, duration of threatening behaviour, duration of displacement behaviour, cortisol levels, and musk secretion levels. If data conform to a normal distribution, the t-test was used to test the differences between the two groups. Otherwise, the Mann-Whitney U-test was used. Spearman rank correlation test was used to examine the relationships between the clustering results of musk deer and age, as well as musk secretion levels.

## **Results**

### ***The reactive behavioural-physiological characteristics of captive musk deer***

Three principal components (PCs) with eigenvalues higher than 1.0 explained 71.568% of the total variance. On the PC1 axis, escape mode, escape duration, escape steps, and stable distance had relatively high positive factor loadings, while alert duration and escape order had relatively high negative factor loadings, characterising the level of fear of humans in captive musk deer; therefore, PC1 was named Fear. On the PC2 axis, two types of aggressive behaviour had relatively high positive factor loadings, characterising the aggressive expression towards conspecifics in captive musk deer; thus, PC2 was named Aggression. On the PC3 axis, cortisol hormones had relatively high positive factor loadings, characterising the physiological stress of captive musk deer; hence, PC3 was named Stress (Table 3).

### ***Assessment of reactivity in captive musk deer***

The clustering results of 26 musk deer, based on the Z-transformed values of nine variables involved in three principal components, indicated that at an Euclidean distance of 20, the captive musk deer could be divided into two groups. One of them contains five individual musk deer and the other contain 21 (Fig 2).

The comparison of variable values between the two groups showed significant differences in alert duration (Mann-Whitney U-test,  $Z = -12.134$ ,  $p = 0.004$ ), number of steps ( $Z = 2.905$ ,  $p = 0.004$ ), escape duration ( $Z = 2.576$ ,  $p = 0.010$ ), and stable distance (t-test,  $t = -2.168$ ,  $p = 0.040$ ). However, there were no significant differences in the duration of displacement behaviour ( $Z = 0.261$ ,  $p = 0.794$ ) and threat behaviour ( $Z = 1.458$ ,  $p = 0.145$ ). Based on these results, the two groups were named the High Reactivity Group (HRG) and the Low Reactivity Group (LRG) (Table 4).

**Table 3.** The results of the principal component analysis of the reactive behave-physiological characteristics of 26 captive musk deer

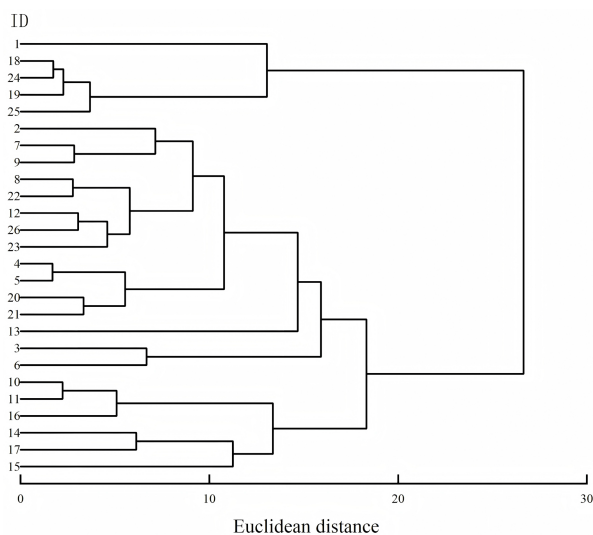
Variable	PC1 (Fear)	PC2 (Aggressiveness)	PC3 (Stress)
Alert duration	<b>-0.861</b>	-0.230	0.064
Escape order	<b>-0.804</b>	-0.335	0.116
Escape mode	<b>0.871</b>	0.271	0.195
Escape steps	<b>0.816</b>	-0.417	-0.060
Escape duration	<b>0.749</b>	-0.451	-0.042
Stable distance	<b>0.529</b>	0.243	-0.189
Displacement behaviour	0.052	<b>0.667</b>	-0.219
Threatening behaviour	-0.256	<b>0.670</b>	0.308
Cortisol hormone	0.273	-0.062	<b>0.913</b>

Note: PC loadings > 0.5 are shown in bold font type.

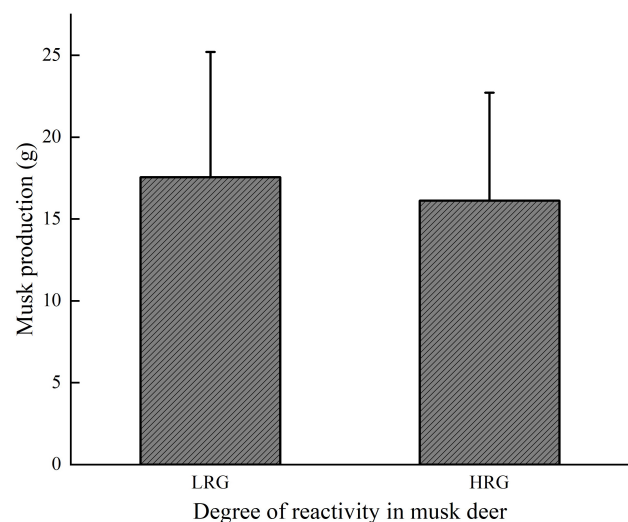
**Table 4.** The mean of variables for two groups in musk deer

Variables	Mean ± SD	
	Low reactivity group (n = 5)	High reactivity group (n = 21)
Alert duration (s)*	125.800 ± 54.133	29.429 ± 22.315
Escape duration (s)*	8.000 ± 17.889	38.19 ± 36.66
Escape steps (steps)*	1.600 ± 3.578	15.000 ± 11.507
Stable distance (m)*	4.425 ± 2.593	7.840 ± 3.268
Displacement behaviour (s)	33.200 ± 18.887	42.905 ± 36.100
Threatening behaviour (s)	0	7.143 ± 11.456
Cortisol hormone levels (ng/g)*	20.730 ± 7.045	30.583 ± 9.583

Note: \* indicates a significant difference between the two groups (p < 0.05).



**Fig. 2.** Dendrogram obtained from cluster analysis of 26 captive musk deer (Ward method, Euclidean distance). Dendrogram generated by hierarchical cluster analysis based on nine quantified variables: alert duration, escape order, escape mode, escape steps, escape duration, stable distance, displacement behaviour, threatening behaviour, and cortisol level. It can be seen from the figure that the 26 musk deer can be distinctly divided into two groups at a Euclidean distance of 20.



**Fig 3.** Differences in musk production among musk deer of various reactivity levels. Designations: LRG stands for the low-reactivity musk deer; HRG stands for the high-reactivity musk deer.

**The relationships between reactivity degree of musk deer, age, and musk secretion**

Age was significantly correlated with domestication group (Spearman  $r = 0.436$ ,  $p = 0.026$ ): on average, LRG animals were older than HRG animals (median age difference test:  $Z = -2.18$ ,  $p = 0.029$ ). There is a slight biological trend for the musk secretion of musk deer in the low reactivity group to be higher than that in the high reactivity group, but it is not significant ( $t = 0.423$ ,  $p = 0.676$ ) (Fig 3).

**Discussion**

In tests of animal reactivity to humans, the distance between humans and animals is a strong indicator of the animal level of fear (Sinn et al., 2014; Yang et al., 2021). In this study, the distance between the musk deer and the keeper had a high positive factor loading on PC1, indicating that the fear of humans is positively associated with the principal components. Individuals with strong reactivity should have a higher degree of fear (Han-

sen Wheat et al., 2019). Therefore, higher scores on these components correspond to higher reactivity degrees in our musk deer (since those individuals show more fear, aggression, and stress). Based on the principal components, it can be inferred that musk deer with high reactivity exhibit a high degree of fear towards humans, strong aggression towards conspecifics, and high levels of environmental stress, which are part of a behavioural and physiological syndrome.

Captive breeding and wild release are important tools for the recovery of wild animal populations (Ebenhard, 1995). However, the success rate of captive breeding and wild release of threatened wildlife for conservation purposes is not ideal, and an important reason is that captive animals typically exhibit changes in natural behaviour compared to the fitness of wild animals (McDougall et al., 2006; Watters & Meehan, 2007; IUCN/SSC, 2013). For example, the captive *Panthera leo* (Linnaeus, 1758) has weakened predatory abilities and reduced vigilance, leading to poor survival capabilities after their return to the wild (Hunter et al., 2013); The survival rate of juvenile *Trichosurus vulpecula* (Kerr, 1792) released into the wild after being raised in captivity shows significant differences, which are related to the individual level of exploratory behaviour and their degree of adaptation to humans (Mella et al., 2022). According to the PCA results of our study, different individuals of musk deer may exhibit varying degrees of fear towards humans, social tolerance, and physiological stress levels (with LRG individuals more likely to show weaker reactivity). A noteworthy limitation of our study is that, while we were able to categorise the 26 musk deer into groups via clustering analysis, we did not identify an effective method to distinguish the specific relationship between reactivity intensity and age for each individual. Nevertheless, our findings indicate that individuals in the low-reactivity group had a significantly higher average age than those in the high-reactivity group. This suggests that with increased duration in captivity and adaptation to the captive environment, musk deer tend to exhibit lower levels of reactivity. Humans have been confirmed as a strong disturbance factor for both wild and captive musk deer (Meng et al., 2010; Yang et al., 2021). Therefore, the adaptability of musk deer that have undergone long-term captivity and their reduced vigilance to wild conditions after being released into the wild should be taken into consideration.

Aggressive behaviour in animals is an important behavioural characteristic used to defend resources, territory, and to compete for mates (Wang et al., 2024). Whether in the wild or in captivity, aggressive behaviour is a key behavioural strategy for ensuring fitness (Biro & Stamps, 2008). However, in captivity, the importance of expressing aggressive behaviour may decline as domestication level rises or as animals adapt to environments different from the wild (Brust & Guenther, 2015; Diakos et al., 2024). In our study, musk deer with low reactivity may exhibit lower levels of fear, stress, and reduced expression of aggressive behaviour. Compared to high-reactivity individuals, they can allocate more energy toward growth and reproduction, suggesting a higher degree of adaptability to captive environments.

Animal domestication is fraught with difficulties and is a slow process, primarily due to inappropriate food under captive conditions, a lack of a dominant hierarchy, slow growth rates, low reproductive intention, excessive aggression, and stress caused by excessive caution (Diamond, 2002). Furthermore, tameness, which is the initial stage of animal domestication, is particularly important. It can be divided into two types, namely active tameness (actively approaching humans) and passive tameness (reduced reactivity to humans) (Matsumoto et al., 2021). In our study, no musk deer exhibited active tameness when the keeper entered the enclosure, and only four musk deer did not show avoidance behaviour, confirming the alert and timid nature of captive musk deer (He et al., 2014), which also indicates one of the reasons for the difficulty in their complete domestication. Furthermore, in current captive environments for musk deer, all-male enclosures are a common configuration, where aggressive behaviour is generally intense among male units. The high frequency of aggressive interactions between individuals impedes the stabilisation of social hierarchies and the establishment of dominance structures (Kleindorfer et al., 2024). This forces musk deer to expend greater energy on defense or maintaining social status, thereby reducing the energy available for growth and other activities. This may serve as another critical reason for the incomplete domestication of musk deer under present conditions.

Musk is a secretion from the glands in the scent sacs of male musk deer, which is stored and matured within the sac and is widely used in the

perfume and traditional Chinese medicine industries (Wang, 2023). In the wild, during the musk secretion period, the scent sacs of musk deer are full, and males expose and scatter musk on the ground or tree trunks by colliding and squeezing, marking their territory and attracting females, which is an important chemical communication pheromone for musk deer (Zhang, 2021). In captive environments, the amount of musk secretion is significantly related to personality (Qiao et al., 2018), behavioural diversity (Bai et al., 2019), and hormones (Sun et al., 2020). In our study, however, the reactivity level had no significant effect on musk secretion. This suggests that the modern communal captive-breeding model has minimal impact on musk production in young males. It also indicates that obtaining musk via non-invasive extraction from live deer is feasible without compromising yield. Additionally, since female musk deer are responsible for giving birth and raising offspring, it is more challenging to conduct related work on them. The subjects of this study were only male musk deer. Therefore, the conclusions of this study are applicable to males only.

### Conclusions

Based on our study, musk deer with low reactivity are less disturbed by humans and conspecifics and have lower level of stress, leading to the inference that they are better adapted to the captive environment. In contrast, individuals with high reactivity are more in line with their nature, being timid and cautious, and are more suited to living alone, with better-preserved wildness, leading to the speculation that they are more suitable for reintroduction into the wild. Furthermore, there were no significant differences in musk secretion between musk deer of different reactivity levels. This leads to recommendations for the breeding farm to construct different breeding environments for musk deer based on varying reactivity purposes. For those intended for release, they should be kept solitary and have minimal contact with humans; for those intended for musk extraction, they can be kept in groups, but the units arrangement should still be considered to avoid excessive conflict among individuals. Additionally, for other captive wild animals, the idea that prolonged captive breeding may inadvertently select for tameness at the expense of wild behaviour is likely applicable to other threatened wildlife breeding programmes.

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## ОЦЕНКА РЕАКТИВНЫХ ПОВЕДЕНЧЕСКО-ФИЗИОЛОГИЧЕСКИХ ХАРАКТЕРИСТИК *MOSCHUS CHRYSOGASTER*, СОДЕРЖАЩИХСЯ В НЕВОЛЕ: ПОСЛЕДСТВИЯ ДЛЯ СОХРАНЕНИЯ EX-SITU И РАЗВЕДЕНИЯ В НЕВОЛЕ

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Перемещение, разведение в неволе и реинтродукция в дикую природу часто используются для сохранения исчезающих видов животных. Однако в неволе дикие животные могут развивать поведенческие и физиологические особенности, схожие с признаками одомашнивания, такие как снижение реактивности (подобно большей одомашненности), что может негативно сказаться на их реинтродукции в дикую природу. Данное исследование проводилось с января 2021 года по декабрь 2023 года на ферме по разведению *Moschus chrysogaster* в уезде Чжуанлан провинции Ганьсу, Китай. В ходе исследования была зафиксирована интенсивность реактивного поведения 26 самцов *Moschus chrysogaster*, в частности, их реакции избегания по отношению к смотрителю загона и агрессивное поведение по отношению к сородичам. В тот же период были собраны образцы фекалий для определения метаболитов кортизола. Метод анализа главных компонентов был использован для изучения поведенческих и физиологических характеристик выращенных в неволе особей *Moschus chrysogaster* с точки зрения их реактивности. На основе этих характерных показателей был проведен кластерный анализ для оценки степени реактивности отдельных особей *Moschus chrysogaster*, разделив 26 животных на группы с высокой и низкой реактивностью (т.е. более ручные и менее ручные особи). Впоследствии в исследовании изучалась взаимосвязь между степенью реактивности и возрастом, а также объемом мускусного секрета. Результаты показали, что особи *Moschus chrysogaster* с более низкой степенью реактивности проявляли меньший страх перед людьми и более слабое агрессивное поведение по отношению к сородичам. Среди 26 *Moschus chrysogaster* пять особей были отнесены к группе с низкой реактивностью, а остальные – к группе с высокой реактивностью. Степень реактивности отрицательно коррелировала с возрастом. Не было выявлено значимых различий в объеме мускусного секрета между группами с высокой и низкой реактивностью, хотя в группе с высокой реактивностью наблюдалось небольшое, статистически незначимое снижение показателя. На основании данного исследования рекомендуется, чтобы фермы по разведению *Moschus chrysogaster* создавали различные условия содержания в зависимости от целей разведения. Для особей *Moschus chrysogaster*, предназначенных для реинтродукции в дикую природу, рекомендуется поддерживать их одиночный образ жизни и минимизировать контакт с человеком для сохранения возможности выпуска их в условия дикой природы.

**Ключевые слова:** поведенческая адаптация, реинтродукция, рыжебрюхая кабарга, секреция мускуса, управление на основе реактивности, физиология стресса