



Review article

Welfare of farmed musk deer: Changes in the biological characteristics of musk deer in farming environments



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ABSTRACT

Musk deer are an important economic wildlife resource, and long-term over-use has resulted in a sharp population decrease in the wild. Farming of musk deer is important to prevent the shrinking wild population from being hunted for their musk. Musk deer farming has a history of more than 60 years in China, but many problems persist. Musk deer are alert, timid and solitary in the wild, and the captive environment cannot satisfy their natural needs, leading to problems in musk deer farming. Understanding the biological characteristics of musk deer may help to identify ways for improving the welfare of farmed musk deer. In addition to gaining musk, musk deer farming can play a role in the reintroduction of musk deer, which complicates things as musk production requires tame domesticated musk deer whereas successful reintroduction requires untamed and less domesticated ones. In this article, we compare captive musk deer and wild musk deer for morphology, behavior, physiology, genetics, and nutrition, and discuss how to organize farming environment and management to satisfy biological needs of musk deer in order to improve their welfare and increase the population of farmed musk deer.

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1. Introduction

Musk deer (*Moschus* spp.) are small solitary ungulates that are distributed throughout forested and mountainous parts of Asia. They are well known because males secrete musk from the musk gland, or pod, located between their navel and genitals (Green, 1987; Sheng and Liu, 2007). For more than 5000 years, musk has been used in the production of medicines, both as a sedative and as a stimulant to cure a variety of ailments in East Asian countries. Musk is also used as an expensive perfume all over the world, as it is highly valued for both its fixative and scent properties (Mills, 1998; Homes, 1999).

China is one of the largest consumers of musk. Historically, 70–90% of musk worldwide was produced in China (Sheng, 1996; Liu and Tong, 2005). Since the 1980s, the demand for musk has increased sharply, resulting in over-exploitation of musk deer. Combined with habitat loss, this has resulted in a drastic decline in the wild population of musk deer (Homes, 1999; Yang et al., 2003). All musk deer are protected as a Category I key species under the National Wild Animal Protection Law in China. Also, all species of *Moschus* spp. are listed in the Appendix of the Convention on International Trade in Endangered Species of Wild Fauna and Flora and are listed as endangered on the World Conservation Union IUCN Red List.

As the wild musk deer resource is depleted, but demand for musk continues to increase. Thus, farming became an important way to protect this species and also the only legal way to obtain musk. The wild animal breeding industry introduces a gradual process of domestication, and this process unavoidably changes the biological characteristics of animals as they adapt to living in captivity (Trut, 1999). The wild animal breeding industry introduces a gradual process of domestication, and this process unavoidably changes the biological characteristics of animals as they adapt to living in captivity. The degree of domestication and adaptation ability vary between species and depend on their biological characteristics. Some species thrive in captivity, whereas other species do not (Mason, 2010). The degree of domestication and adaptation ability vary between species and depend on their biological characteristics. Some species thrive in captivity, whereas other species do not (Mason, 2010). Musk deer have been farmed in China since 1958 (Zhang, 1983), and although much farming experience has been accumulated, the captive population is plagued with difficulties including disease and high mortality (Parry-Jones and Wu, 2001).

Wild musk deer are characterized as alert, timid, and solitary, and the captive environment cannot satisfy their behavioral and natural needs, which may affect their welfare. Such an effect may in turn affect the success of living in captivity or farming. However, previous studies of musk deer focused on taxonomy (Groves et al., 1995), distribution (Liu and Sheng, 2002; Zhou et al., 2004), enclosure patterns (Liu et al., 2010; Zhang et al., 2010), nutrition (Bai et al., 2009), behavior (Du and Sheng, 1997; Meng et al., 2003; Qi et al., 2013), musk secretion (Li et al., 1980; Hong et al., 1981; Yin and Dai, 1991; Huang et al., 1998; Shrestha, 1998), reproduction (Lang et al., 2012), and disease (Lv et al., 2009). Yet the relationships between inherent

biological characteristics and farming of musk deer have received less attention. Recently, the State Forestry Administration Protection Department of China proposed that the breeding and farming centers also are responsible for protecting the progenitor resources. It is necessary to expand the captive population to provide progenitors for reintroduction of musk deer. For either the production of musk or the reintroduction objective, determining how to preserve the biological characteristics of musk deer is important for their welfare and successful farming. Herein, we discuss the relationships between musk deer morphology, behavior, physiology, genetics, and nutrition and farming with the goal of identifying methods for improving the welfare and population development of farmed musk deer.

2. Morphological characteristics and farming

Musk deer species are small ruminants with slender limbs, weighing 6–15 kg with a length of 60–90 cm. They jump and run well due to their long hind legs and relatively short front legs (Sheng and Liu, 2007). This body structure is suitable for escaping predators in the wild. By contrast, in captivity, frequent and vigorous jumping and running can easily result in injury, sometimes even fatal injury. For example, a musk deer may die after jumping and running violently continuously for half an hour (Dr. Li, Cun-xuan, personal communication). Obviously, the morphological characteristics are closely related with behavior, such that we should consider behavior characteristics in solving the welfare problems of captive musk deer (as described below).

The domestication process has focused on high production and low management costs. The ideal morphology of farmed musk deer includes small tusks, a large musk bag and a limited jumping ability. Farmers tried restraining the hind legs with string to change the deer's appearance to decrease their running and jumping ability. Similarly, people once fixed the tusks using plastics or clipped the tusks of the male musk deer, because the tusks are useless for musk secretion and can cause injury to people or other musk deer. However, both fixing and clipping of the tusks are difficult processes that can easily damage the gingiva and lead to pulpitis.

It is unfortunate that the *Musk Protection and Construct Project of China* in 2002 did not refer to morphological problems of farmed musk deer. Cultivating an appropriate morphology that is suitable for farming is necessary for the continuation of the musk farming industry. However, changes in morphology may impair the ability of musk deer to survive in their natural environment, which is adverse for conservation. Therefore, it is important to separate the different goals of farming programs.

3. Behavioral characteristics and farming

Musk deer are alert, timid, and territorial animals, and these characteristics are useful for their survival in the wild. However, these characteristics negatively influence their management in captivity. For example, routine veterinary inspection is difficult because musk deer are not easy to approach, capture, or restrain. Thus, identifying

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