

Review of the distribution, status and conservation of musk deer in China

Yijun ZHOU¹, Xiuxiang MENG^{1,2*}, Jinchao FENG¹, Qisen YANG³, Zuojian FENG², Lin XIA²
and Luděk BARTOŠ³

¹ School of Life and Environment Sciences, Central University for Nationalities, 27 Zhongguancun Nan-da-jie, Beijing 100081, China; e-mail: mengxiuxiang2006@hotmail.com

² Institute of Zoology, Chinese Academy of Sciences, 19 Zhongguancun Road, Beijing 100080, China

³ Ethology Group, Research Institute of Animal Production, P.O.Box 1, 104 01 Praha 10, Czech Republic; e-mail: bartos@vuzv.cz

Received 30 December 2003; Accepted 8 June 2004

A b s t r a c t. There are five species of musk deer of the genus *Moschus*, in China, occurring in about 17 provinces. We estimate the total numbers in China to be between 220,000 and 320,000. In some areas the populations are in decline, and some are close to extinction due to over-hunting and habitat loss or degradation, the former being the primary threat to musk deer populations. To conserve musk deer, *in situ* protection should be improved, and the present unsustainable forest exploitation in the range areas should be halted. Poaching of musk deer, and smuggling of musk deer products, should be prevented. Domestic use of musk should be restricted. In some areas where musk deer have become extinct or are critically endangered, *ex situ* protection should be introduced. Musk deer farming should be revised and developed according to biological requirements.

Key words: musk deer, *Moschus*, conservation status, China

Introduction

Musk deer *Moschus* spp. are very shy, solitary animals, occurring in at least 13 countries in South Asia, East Asia, Southeast Asia and the eastern parts of Russia. For a long time, musk deer have been valued for their musk, secreted by the musk gland possessed by the male. Musk is one of the oldest raw materials used in perfumery, because of its fixative and scent properties; it is one of the most valuable of all scented animal products, even more expensive than gold (Shrestha 1998, Green 1986). Extensive hunting (legal or illegal) over a long period for musk has resulted in a sharp decline of the populations so that *Moschus* spp. have become endangered or, in some areas, extinct. Since 1979, all musk deer have been included in the Appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). While the conservation status of musk deer in other countries have been reported (Homes 1999), this is the first report for China.

China is one of the largest range countries of all species of *Moschus*. Some species, such as the alpine musk deer *M. sifanicus*, occur in only China (Yang 1999, Sheng 1989), while the forest musk deer *Moschus berezovskii* extends marginally into Vietnam and the black musk deer *M. fuscus* extends into the northern tip of Burma. Wild populations

*Corresponding author

in China have been declining for decades (Sheng 1998), but the gravity of the situation has been underestimated. In order to improve the conservation of musk deer, an overview of their historical population trends and current conservation status is needed. Based on this, realistic strategies for their conservation and the sustainable use of musk can be developed. In this paper, we review the status and conservation of the musk deer in China.

Taxonomy

For a long period, the taxonomy of musk deer has been under discussion (Groves et al. 1987, Flerov 1952). Musk deer were originally classified as members of the family Cervidae (Flower 1875), but more recently, they have come to be regarded by most authors as a separate family Moschidae (Flerov 1952, Groves et al. 1987, Homes 1999). At least four species within the genus *Moschus* are recognized (Green 1998, Groves et al. 1987, 1995); today, most authors regard this number as an underestimate. In China, many different classification systems have been established (Groves 1975, 1986, Grubb 1982, Cai 1981, Wang 1982, Sheng 1994). Recently, it was proposed to increase the number still further; when Li et al. (1999) and Su et al. (2001), on the basis of mitochondria DNA data, recognised *M. anhuiensis*, from Anhui Province, a species which had been described as a subspecies of *M. moschiferus* by Wang et al. (1982) and transferred to *M. berezovskii* by Groves & Feng (1986). There is, however, broad agreement of the recognition of 5 species of musk deer in China (Feng 1985, Groves 1995, Sheng 1998, Yang 1999), and in this review, we will still use the five musk deer taxonomic system: Forest musk deer (*M. berezovskii*); alpine musk deer (*M. sifanicus*); black musk deer (*M. fuscus*); Himalayan musk deer (*M. chrysogaster*); Siberian musk deer (*M. moschiferus*).

Distribution

In China, musk deer extend through most of the forested area, mainly in the alpine or sub-alpine zones. While the five species in China have different distributions, they overlap with each other in some provinces (Fig. 1). The detailed distributions of the five species are as follows:

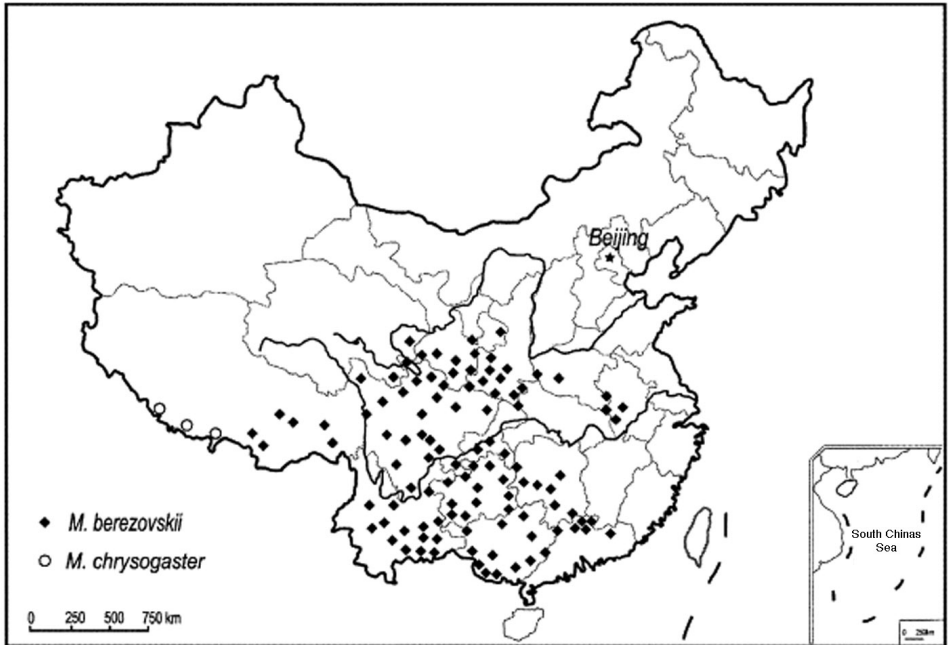
Forest musk deer

This musk deer has the widest range of the 5 species of China, being distributed from Ningxia and Shaanxi in the north to Guizhou and Guangxi in the south, from Anhui and Hunan in the east to Sichuan, Yunnan and Tibet in the west. Its distribution thus covers 13 provinces: Sichuan, Yunnan, Guizhou; Tibet, Qinghai, Gansu, Shanxi, Shaanxi, Anhui, Ningxia, Hubei, Hunan and Guangxi (Fig. 1).

Alpine musk deer

This species is endemic to China, and specifically to the Tibet-Qinghai Plateau, where it is distributed in the plateau-mountains and the adjacent regions of western China. It has been recorded in Tibet, Qinghai, Yunnan, Ningxia, Xinjiang and western Sichuan (Fig. 1).

(a)



(b)

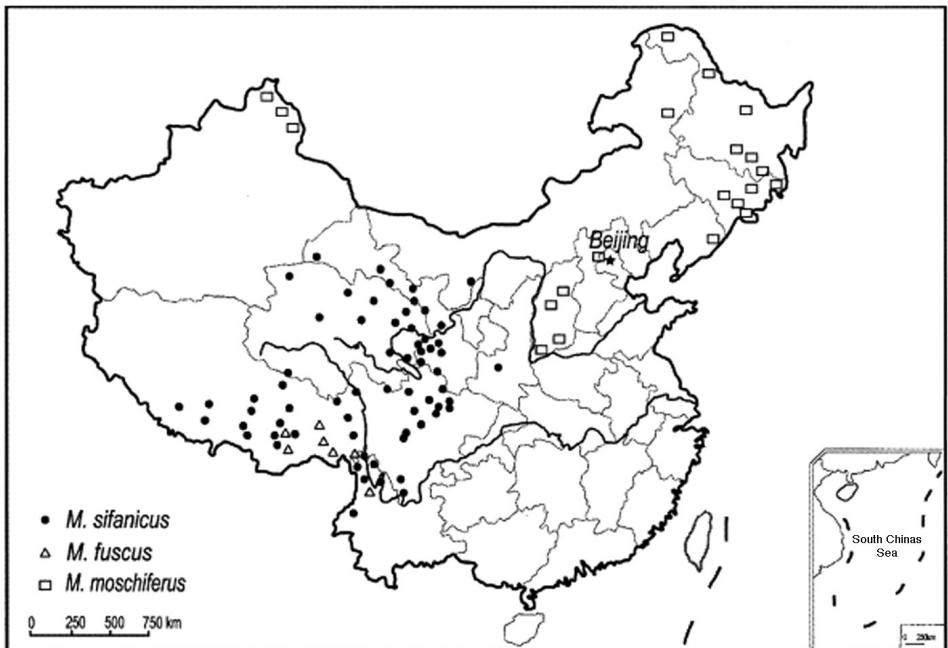


Fig. 1. Current distribution of musk deer in China: (a) *Moschus berezovskii* and *M. chrysogaster*, and (b) *Moschus moschiferus*, *M. sifanicus* and *M. fuscus*.

Black musk deer

This species, described only 20 years ago, is confined to western Yunnan and southeastern Tibet, including Mt. Gaoligong, Bijiang, Chayu and Motuo, and Milin (Y a n g 1999, S h e n g 1998); its range extends marginally into Burma and probably Nepal (G r o v e s et al. 1995). Its habitat requirements are very specific and limited.

Himalayan musk deer

This species is found exclusively in the Himalayan regions. In China, it occurs only on the slopes of Himalayas in Tibet (Y a n g 1999, S h e n g 1998).

Siberian musk deer

This species is distributed in northeastern China, mainly in Da Hinggan Ling, Xiao Hinggan Ling and Changbai Mountain in Heilongjiang, and in Jilin and Liaoning Provinces, but it also occurs in Shanxi, Hebei and Inner Mongolia.

Material and Methods

For a long period, due to the lack of funds and the wide distribution of musk deer, no surveys were carried out at the national level. In only parts of their range have scientific field studies and counts been conducted (Y a n g 1989,1994, S h e n g 1992). An accurate assessment of the total musk deer population in China is not therefore available, and can only be attained from estimates of historical trends in musk production (S h e n g 1998, Y a n g 1999).

Based on the data of the musk production from 1950 to 1980, from provincial statistical bureau and medicine companies in the range provinces, and a synthesis of accessible field survey reports (Y a n g 1989,1990,1999, S h e n g 1990,1992, W a n g 1988, Z h e n g 1979), we have estimated the wild populations of musk deer in China. The population status and trends of each musk deer species can be estimated as follows.

Results

Population

Siberian musk deer

This species was abundant in forested regions of northern China in 1950s–1960s (S h e n g 1998). A field survey conducted from 1983 to 1984 showed that the population reached nearly 20,000 in Daxinganling and the adjacent regions in the early 1980s. Later, as the result of a catastrophic forest fire in 1987, the population declined (M a 1986). Now, in its entire range in northeastern China (including Jilin, Inner Mogonia, Liaoning and Heilongjiang), there are probably no more than 20,000 musk deer (S h e n g 1998). In other range provinces such as Shanxi and Hebei, although in the past the Siberian musk deer was abundant, the species is today quite rare through being over harvested.

Forest musk deer

There were more than 1 million forest musk deer in the 1960s according to records of musk production, but only 600,000 remained by the second half of the 1970s, due to over-hunting (S h e n g 1992, 1998). During the 1980s in particular, when the price of musk increased sharply, the pressure of harvesting intensified and the population further declined sharply to some 200,000–300,000. The decline has continued to some 100,000–200,000 in the 1990s (S h e n g 1992,1998).

Alpine musk deer

Historically, alpine musk deer were abundant in the ethnic minority regions of Qinghai, Tibet and northwestern Sichuan (H u 1984, Y a n g 1999). According to the survey conducted by the Medicine Company of China in 1961, there were 180,000 alpine musk deer in Qinghai province in 1960s, but only 30,000 were left in 1970s. S h e n g (1998) reported that this species was abundant in Xinglongshan National Nature Reserve, Gansu Province, within typical musk deer habitat areas, and estimated the numbers of alpine musk deer at about 5,000 at the beginning of 1990s, with a density of 23–51 animals /km². Kang later conducted another census and found that the total population had declined to about 1000 between 1996 and 1999 (K a n g 2003, personal communication). At present, the total population of alpine musk deer is not more than about 100,000 (S h e n g 1998).

Black musk deer

This species is distributed in only a few regions of China, and in limited habitats, for which the population size is unknown. We estimate it to be at the edge of extinction, with a population less than 10,000 animals (S h e n g 1998).

Himalayan musk deer

As is the case with black musk deer, this species occurs in China in low numbers because of its narrow distribution and requirements for specific habitats on the slopes of Himalayas in Tibet.

In summary, there are 100,000–200,000 forest musk deer, 20,000 Siberian musk deer and 100,000 alpine musk deer. As far as black musk deer and Himalayan musk deer are concerned, although their populations remain unknown, it is likely to be relatively low because of their limited distributions. In conclusion, the recent populations of musk deer in China can be estimated to reach 220,000–320,000 musk deer in total.

Musk deer farming and numbers in captivity

Farming of musk deer started in 1958 in China the production of musk, and to protect declining populations. Since then, efforts have been made to expand musk deer farming, and many state farms have been established. In the early 1980s, musk deer farming reached its climax and the peak population in captivity was more than 3,000 (Z h o u 2000). Nevertheless, musk deer are difficult to manage and breed on farms, because of their solitary behavior, territoriality and excitability (Z h a n g 1979, H o m e s 1999). For this reason,

their farming has not been successful on many farms, and most established farms have had to be closed (S h e n g 1998).

The most commonly farmed species was the forest musk deer, and to some extent also the alpine musk deer, with the other three species being kept rarely. Some authors have stated that, of the five species, the forest musk deer has been relatively the easiest to be farmed (Z h a n g 1979, D e n g 1989).

At present, there are several farms (called Musk Deer Breeding Centers) where musk deer are kept (Table 1). The farm located in Dujiangyan, Sichuan Province, holds the largest captive population in China, about 1300 head. In addition, about 250 alpine musk deer are kept at a Breeding Center in Xinglong Mountain Nature Reserve in Gansu Province. In total, some 1,900 animals are being farmed in China.

Musk deer are rarely kept in zoos because their shy, inconspicuous lifestyle makes them unattractive for the visitors (H o m e s 1999). The number of musk deer kept in zoos in China is around 50.

Table 1. The population of captive musk deer in China.

| City / Province | Farmed species | Population | Source |
|---------------------|--|-------------------|------------------------|
| Shanghai, Fujian | <i>M. berezovskii</i> ; <i>M. sifanicus</i> | 20 | visited by the authors |
| Xinglongshan, Gansu | <i>M. sifanicus</i> | 250 | visited by the authors |
| Zhengping, Shaanxi | <i>M. berezovskii</i> | 130–150 | Z h o u 2000 |
| Foziling, Aihui | <i>M. berezovskii</i> | 50–60 | Z h o u 2000 |
| Chongming, Shanghai | <i>M. berezovskii</i> ; <i>M. sifanicus</i> | 230–240 | Z h o u 2000 |
| Dujiangyan, Sichuan | <i>M. berezovskii</i> ; <i>M. sifanicus</i> | 1200–1300 | Z h o u 2000 |
| Miyaluo, Sichuan | <i>M. berezovskii</i> | Recently closed | |
| Maerkang, Sichuan | <i>M. berezovskii</i> | Recently closed | |
| Mentougou, Beijing | <i>M. berezovskii</i> ; <i>M. sifanicus</i> ; <i>M. moschiferus</i> | Recently closed | visited by the authors |
| Heilongjiang | <i>M. moschiferus</i> | Recently closed | Z h o u 2000 |
| Tiane, Guangxi | <i>M. berezovskii</i> | no data available | X u 2001 |

Use and trade of musk

The musk secreted by the musk gland of the males has been used in the perfumery industries for a long time for its intensity, persistence and fixative properties. In Asia, including China, it has also long been used in traditional medicine as a sedative and as a stimulant to treat a variety of ailments (S h e n g 1998, Y a n g 1999, H o m e s 1999). In China, musk deer have been hunted for musk, and musk purchasing has been conducted in rural markets or via local medicine company.

In China, the perfume industry has remained on a small scale. Mainly in Shanghai, perfume is produced based on natural musk, but production is not high at present (Z h a n g 1983). The use of musk in the perfume industry in China has decreased because of the high price, and because of animal welfare and species conservation concerns. In China, study of synthetic musk compounds is well advanced, and some of these products have begun to replace natural musk in the perfume industry. Complete cessation of the use of natural musk in the perfume industry is likely within a few years (H o m e s 1999, Z h a n g 1989).

The effects of musk have been known in TCM (Traditional Chinese Medicine) for several thousands of years; musk being contained in about 300 pharmaceutical preparations (S h e n g 1992). China has a high domestic demand for musk (H o m e s 1999), and this originates from both legal and illegal sources within the country. The total demand for musk reaches 500–1000 kg per year in China (S h e n g 1998).

Domestic market in China

Before the middle of the 1980s, smuggling was rare in China. Poached musk pods were all traded within the domestic market, mainly via local medicine companies; hence the data collected from provincial medicine companies would probably have reflected the true domestic trade (Y a n g 1999, S h e n g 1998). In the 1950s, annual raw musk production was 1400–1700 kg; in the 1960s 2000–3000 kg. Annual production thereafter decreased to 1500 kg in 1970s and in the early 1980s, and not much musk was being purchased by local medicine companies due to the increasing smuggling of musk abroad (S h e n g 1998), although it is possible that the gradually falling domestic trade quotas reflect the fact that musk deer populations in China were already declining.

International trade

China does not show up as a major trader of raw musk on the international market, but it is said to be the biggest exporter of musk derivatives (H o m e s 1999). Official Japanese trade figures indicated that between 215 kg and 300 kg of raw musk were imported to Japan from China annually from 1981 to 1985 (G r e e n 1989). Before the 1970s, raw musk in China was mainly in domestic use (S h e n g 1998). At present, China continues to export musk mainly in the form of musk derivatives (H o m e s 1999).

Smuggling

The worldwide demand for musk is larger than the amount legally available and certainly exceeds the supply from the export market of musk deer range countries (H o m e s 1999), and the price of musk has therefore increased recently by about 35–40% (H o m e s 1999, S h e n g 1998). The current price is about US\$ 12–14/g in Europe and in South Korea, while in the perfume industries of France the price has reached as much as US\$ 50/g (H o m e s 1999). According to the figures by TRAFFIC-Japan, in 1979–1985 musk illegally imported to Japan, namely via Hong Kong, reached 1154.4 kg (S h e n g 1992). At present, the smuggling of musk may still exist in China, but information about the routes and amounts is not available.

Threats to the musk deer

Musk deer inhabit forested mountainous regions which provide them both food and shelter (Y a n g 1999). Musk deer habitats are still being converted for settlements, agriculture and so forth for the continually growing human population, so the five species live under constant pressure from humans. The two primary types of threat causing decimation of populations in China are therefore loss of habitat (Y a n g 1989, 1999) and poaching (W e m m e r 1998, G r e e n 1986, J a c k s o n 1979). These are in addition to natural predation.

Hunting as a threat

In China, musk deer have been hunted for thousands of years despite the fact that the meat is not considered tasty and the skin is not valuable as the hairs fall out easily (H o m e s 1999). The main reason for the intense hunting of musk deer has always been the demand for musk. Musk deer may either be hunted as the prime target for their glands, or killed incidentally when hunting other animals.

Hunting of musk deer in China historically was not subjected to a licensing system before the enacting of the Wild Animal Protection Law of 1988, and the policy was not carried out that shooting quotas should be fixed on the basis of counts of the musk deer population, so for a long time, there was no legal hunting, but only poaching, which was the prime cause for the reduction of musk deer (S h e n g 1998, Y a n g 1989,1999).

Traditionally, musk deer are hunted with dogs and hand-made-guns; considering that the chance of killing musk deer depends on their population density, this method would not be likely to cause their extinction. In the last two decades, poachers have been using modern guns, and snares made of wire (L i u 2000), the latter in particular offering easy kills. A lot of females and young die, though they have no musk (Y a n g 1989, 1994, S h e n g 1998, 1990, 1992). It is particularly the expansion of snare use that has brought musk deer have close to extinction. Y a n g (1989) reported that the snares were set at a density of 15 km² in Baiyu County, Sichuan Province. S h e n g (1998) reported that 11704 snares were spotted in the Xinglongshan National Nature Reserve in 1980, causing the death of total of 213 musk deer. In Changdu County of Tibet, 62800 snares were destroyed by the local forestry staff during the period from 1991 to 1992 (Y a n g 1999). From these data the scale of the threat of snare-trapping to musk deer can be imagined.

For this study we took into consideration the following average parameters: weight of musk in one gland: 15 g (Y a n g 1989); number of musk deer killed: three animals taken to obtain one male musk deer with a sufficiently large musk gland (G r e e n 1986, J a c k s o n 1979). In the 1950s, when there were 2–3 million musk deer in China (S h e n g 1990, Z h o u 2000), the annual musk production reached 1400 kg–1700 kg (S h e n g 1999), which is equivalent to 280,000–340,000 musk deer killed annually. This represented 10% or so of the total wild population only, and was lower than the estimated natural breeding rate of 20% (S h e n g 1999). This should not, therefore, affect the population (Y a n g 1999). During the 1960s, 2,000 kg–3,000 kg musk was harvested annually (S h e n g 1999) from about 400,000–500,000 musk deer. Musk use had declined to about 1,500 kg per year in 1970s (maximum musk production of one year was still around 3000 kg), representing 300,000 animals killed (600,000 at the peak) (S h e n g 1999). As a result, during the 1970s the musk deer in China declined to about one million (S h e n g 1999). In the late 1970s and early 1980s, the population suffered further from the destructive methods of hunting. Stimulated by the extremely high price, several times the former price, the musk deer declined by 10–30% per annum (S h e n g 1999). In many areas, musk deer have almost disappeared, even in the high mountainous regions where they should be difficult to hunt (Y a n g 1999).

Habitat loss and degradation as a threat

Habitats of musk deer in the alpine and subalpine regions are used for harvesting timber and firewood, which is drastically destroying musk deer habitat. According to data collected

from Provincial Statistical Bureau, about $5.875 \times 10^8 \text{ m}^3$ of timber was harvested from 1950 to 1982 in western Sichuan, and in only 32 years the area of forest decreased by 68,900 km² due to overexploitation. So in this main range province in China, forest logging led to the present decrease of the musk deer population (Y a n g 1999), but these should not be case in the future since the government of China made the decision to stop the logging of natural forests over the country in 1998.

Catastrophic forest fire has also destroyed musk deer habitats. For example, the great forest fire in Daxinganling in 1987 directly resulted in the reduction of the Siberian musk deer population of northeastern China (M a 1986, S h e n g 1998). A comparative field survey indicated that the density of musk deer in virgin mixed forests reached 9.15/km² in Baiyu County in northwestern Sichuan, while in clearing which had been artificially fired to be used as religious sites, the number was only 5.81 animals km² (Y a n g 1989).

Musk deer habitats in the subalpine regions of northwestern China have increasingly been used as pasture land. Owing to the overexploitation of the pastures themselves, domestic animals enter the forest to compete for shrub and undergrowth with musk deer. Husbandry, especially the nomadic pattern, can have a dramatic impact upon the populations of musk deer, especially the alpine musk deer which occurs in more open country at high elevation (Y a n g 1999). For example, in southeastern Tibet, where alpine musk deer occurred, Y a n g (1994), in the course of a survey of seasonal movement of musk deer, and found that numbers were significantly correlated with the movement of the domestic animals in the forest.

In summary, the populations of musk deer presently inhabit significantly smaller areas and their occurrence is more fragmented than in the past. In parts of their distribution, populations are on the edge of extinction; alpine musk deer, for example, formerly lived in Minghe, Yedu, Huangzhong and Pingan Counties in Qinghai Province, but are now extinct in all of them due to habitat loss (Z h e n g 1984).

Natural predators

In the wild, musk deer are subject to a number of natural predators, against which they defend themselves mainly by hiding or by their jumping gallop. The main predators of musk deer include wolf (*Canis lupus*), fox (*Vulpes vulpes*) and wild cat (*Prionailurus bengalensis*). In addition, the fawns are attacked by large birds of prey such as *Corvus macrohynchus*, *Aguila hemilasius* and *Buteo hemilasius*. In recent years, predator populations of mammalian have declined for many reasons, so they no longer have a significant impact on the musk deer population (W a n g 1996). In Xinglong Mountain National Natural Reserve, the young alpine musk deer form up to 17%–22% of the diet of the fox and wild cat (G a o 1997).

Discussion

The conservation strategies

All musk deer species are included in the Appendices of the Convention on International Trade in Endangered Species of Fauna and Flora (CITES), so the trade in musk is controlled at the international level. In China, the government now pays much more attention to musk deer conservation through *in situ* and *ex situ* protection. All species of musk deer are listed in the Second Category of the List of State Key Protected Wild Life, for which

hunting and free trading are banned. The Chinese government has also launched a series of laws and regulations to preserve rare animals and their habitat, which includes the Wild Animal Protection Law, the Forestry Law and the Environmental Protection Law. Under the protection of the law, illegal activities such as poaching, trapping, selling and trading of musk and musk deer will be severely punished.

In situ protection

At present, in China, *in situ* protection for musk deer, which means that the musk deer are protected in their range areas, has been much improved. In areas with musk deer, poaching and non-sustainable timber harvesting have been banned. The Chinese government has established a large number of national, provincial and local nature reserves as refuges for wildlife, and most of these are established within musk deer range. Within these established reserves, the prospects for musk deer preservation are quite good. For example, in Ganzi Autonomous Region of northwestern Sichuan Province, adjacent to the Tibetan plateau and Hengduan Mountains, musk deer were formerly abundant; the density of forest musk deer in shrub and mixed coniferous forest habitats 9.02 animals km² and 9.15 km² respectively in 1989 (Yan g 1989), but almost reached extinction in 1994, being rare even where they were formerly abundant years ago (Yan g 1999). In comparison, in Tangjiahe National Nature Reserve in Sichuan province, the density of musk deer was 9.88 animals km² in 1988 and has remained relatively stable, ten years later being 8.64 km² (Wan g 1988, Yan g 1999). From comparison of these two instances, it can be seen that establishing a nature reserve has played an important role in maintaining musk deer numbers. Considering the wide distribution of musk deer in China, however, more reserves are needed to protect them more effectively. In addition, the management of musk deer outside the nature reserves should be improved, and reliable field assessments of numbers should be carried out across the country as a basis for appropriate wildlife management.

Ex situ protection

In the areas where musk deer have become extinct or endangered, *ex situ* protection can be considered. At present, the main means of *ex situ* protection of musk deer is captive breeding. Although musk deer farming in China is relatively successful compared to other countries (Shrestha 1998), breeding musk deer on many farms in China has failed (Sheng 1998). For effective reintroduction of musk deer, experiments with releasing captive bred deer are needed. Farmers need to be better organized to share experiences, and scientific investigation should be involved to improve farm production. In some range regions where musk deer occur at high density, the sustainable use of musk should be experimentally investigated, by the extraction of musk from live animals in the wild, since currently to extract musk means to kill the wild deer first (Homes 1999). Through this practice, a reasonable income for the people in rural alpine areas could be achieved, and utilization of the musk deer and its protection could be harmonized and smuggling and poaching can be significantly decreased.

Restriction of use and trade

Further improvement of *in situ* protection of musk deer needs international cooperation to control the world wide trade of musk, and the smuggling of musk and poaching of musk

deer must be completely banned. The domestic demand for TCM should be monitored and controlled, and clear product labeling of medicinal and perfume items containing natural musk together with accompanying official permits should be brought into use.

Acknowledgements

We would like to thank Professor Colin Groves for his comments on the earlier draft of the manuscript and for his kind help in improving English. This research was supported by the “211 Researching Projects” of Central University for Nationalities (CUN) of China, the Chinese Academy of Sciences (No. KZ951-A1-105) and National Natural Sciences Foundation of China (No. 39870137).

LITERATURE

- DENG F. 1989: The farming of musk deer. *Shaanxi People's Education Press, Xian*.
- FLOWER W. H. 1875: On the structure and affinities of the musk deer (*Moschus moschiferus*, Linn.). *Proceedings of the Zoological Society of London 1875:159–190*.
- GAO Y. T. 1963: The taxonomy of musk deer in China. *Acta Zoologica Sinica 15 (3):479–487 (in Chinese with English abstract)*.
- GAO Z. 1997: The influence on musk deer in Xinglongshan Reserve by carnivorous mammal. *Chinese wildlife 18(5):17–18*.
- GREEN M.J.B. 1986: The distribution, status and conservation of Himalayan musk deer (*Moschus chrysogaster*). *Biological Conservation 35:347–375*.
- GROVES C. P. & FENG Z. 1986: The taxonomy of musk deer in Anhui Province. *Acta Theriologica Sinica. 6(2): 105–106 (in Chinese with English abstract)*.
- GROVES C. P., WANG Y. & GRUBB P. 1995: The taxonomy of Moschus. *Acta Theriologica Sinica 15(3): 181–197 (in Chinese with English abstract)*.
- GRUBB P. 1982: The systematic of Sino-Himalayan musk deer (*Moschus*), with particular reference to the species described by B. H. Hodgson. *Säugetierkundliche Mitteilungen 30:127–135*.
- JACKSON R. 1979: Aboriginal Hunting in West Nepal with reference to musk deer (*Moschus moschiferus*) and Snow Leopard (*Panthera uncia*). *Biological Conservation 16:63–72*.
- HOMES V. 1999: On the scent: Conservation Musk deer –the uses of musk and Europe's role in its trade. TRAFFIC Europe.
- LIU Z. & SHENG H. 2000: The status and conservation of the isolated alpine musk deer population in the forest region of Helan Mountain. *Acta Ecology 20(3):463–467 (in Chinese with English abstract)*.
- MA Y. 1986: The mammals of Heilongjiang. *Heilongjiang Sciences and Technology Publishing House, Haerbing (in Chinese)*.
- SHENG H. 1990: Musk deer and musk. In: Wang S. & Hu Z. (eds), *Dissertations in Zoology. Beijing Normal University Publishing House, Beijing*.
- SHENG H. 1998: *Moschus* spp. In: Wang S. (ed.), *China Red Data Book of Endangered Animals. Science Press, Beijing, Hong Kong, New York*.
- SHENG H. & OHTAISHI N. 1993: The status of deer in China. In: Ohtaishi N. & Sheng H. (eds), *Deer of China: Biology and Management. Elsevier Science Publishers, Amsterdam, The Netherlands*.
- SHRESTHA M. N. 1998: Animal welfare in the musk deer. *Appl. Anim. Behav. Sci. 59:245–250*.
- WANG H. & SHENG H. 1988: The population density, conservation and exploitation in northwestern of Sichuan Basin. *Acta Theriologica Sinica 8(4):241–249 (in Chinese with English abstract)*.
- WANG X. 1996: The research of natural resources in Xinglongshan National Reserve, Gansu Province. *Ganshu nationality press, Lanzhou*.
- WANG Q., HU X. & YAN Y. 1982: A new subspecies of Siberian musk deer (*M. moschiferus*) in China. *Acta Theriologica Sinica 2(3): 133–138 (in Chinese with English abstract)*.
- WEMMER C. 1998: Deer: Status Survey and Conservation Action Plan. *IUCN/SSC Deer Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK*.

- YANG Q., HU J. & PENG J. 1989: The study on the density of forest musk deer in Baiyu County. *Acta Theriologica Sinica* 10(4): 255–262 (in Chinese with English abstract).
- YANG Q., HU, J. & PENG J. 1990: The research on population dynamic of *Moschus moschus* in northern Mt. Hengduan. *Journal of Sichuan Teacher's College* 10(4): 329–306 (in Chinese with English abstract).
- YANG, Q. & FENG Z. 1999: The status and the sustainable use of musk deer in China. In: Hu Jinchu & Wu Yu (eds), The resource of vertebrate animals in Sichuan. *Sichuan Science and Technology Press, Chengdu*.
- ZHANG B. 1979: The Taming and Raising of musk deer. *Agriculture Press, Beijing*.
- ZHANG B. 1983: Musk deer: Their capture, domestication and care according to Chinese experience and methods. *Unasylva* 35:16–24.
- ZHENG S. & PI N. 1979: Study on ecology of the musk-deer (*Moschus sifanicus*). *Acta Zoologica Sinica* 25 (2): 176–186 (in Chinese with English abstract).
- ZHENG S. & PI N. 1984: The musk pod of Alpine Musk Deer. *Acta Theriologica Sinica* 4(1): 35–42 (in Chinese with English abstract).
- ZHOU J. 2000: The farming of musk deer in Sichuan Province. *Chinese Wildlife* 4:14.