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Conservation status and causes of decline of musk deer (*Moschus* spp.) in China

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Abstract

Five species of musk deer (Forest musk deer *Moschus berezovskii*, Alpine musk deer *M. sifanicus*, Black musk deer *M. fuscus*, Himalayan musk deer *M. chrysogaster* and Siberian musk deer *M. moschiferus*) occur throughout 17 provinces in China, and all were listed in the second category of the Chinese State Key Protected Wildlife List in 1998. Among these species, the Forest musk deer has the widest distribution, and its population is estimated at about 100,000–200,000 individuals in the wild. Additionally, there are about 100,000 Alpine musk deer and 2000 Siberian musk deer. As for the Black musk deer and Himalayan musk deer, which occur only in parts of Yunnan Province and Tibet, their populations remain unknown but they can be estimated to be rare due to their narrow and limited distribution. Furthermore, there are some 1900 musk deer kept in farms in China. Generally, the musk deer population has been declining due to over-hunting for musk and to loss of habitats. However, the Chinese government is greatly concerned with wildlife protection today. A series of laws and regulations have been launched and many natural reserves and national parks have been established as refuges for this animal, most of which, are within the musk deer's range, and should have positive effects for musk deer conservation.

Keywords: Musk deer; Conservation; Status; Population; Habitat

1. Introduction

Musk deer (*Moschus* spp.) are solitary ruminants, distributed throughout the forest and mountainous parts of Asia, from just north of the Arctic Circle southward to the northern edge of Mongolia and to Korea. Further south, avoiding the Gobi desert, the musk deer occurs in China, Burma, Northern India, Northern Vietnam and the Himalayan region (Flerov, 1952; Green, 1986). The taxonomy of musk deer remains debatable (Groves and Grubb, 1987; Flerov, 1952: see later), but at the present time four or more species of musk deer are recognized (Zhang, 1998), and all have been included in the Appendices of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) since 1979.

China is one of the most important range countries of musk deer distribution, but the number of species of the genus *Moschus* in China is still undetermined (Sheng, 1998), and a variety of classification systems have been proposed (Sheng, 1998; Yang and Feng, 1998; Groves, 1975; Groves and Feng, 1986; Groves et al., 1995; Grubb, 1982; Cai and Feng, 1981; Wang et al., 1993), although most now believe that there are five musk deer species in China, as follows: (1) Forest musk deer *M. berezovskii*, (2) Alpine musk deer *M. sifanicus*, (3) Black musk deer *M. fuscus*, (4) Himalayan musk deer *M. chrysogaster*, and (5) Siberian musk deer *M. moschiferus*. Su et al. (2001) have recently added a sixth, the Anhui musk deer *M. anhuiensis* (formerly considered a subspecies of *M. berezovskii*).*M. anhuiensis* occur is scattered, isolated regions over most of China, and are all protected in the second grade of the Chinese State Key Protected Wildlife List in 1998 (CSKPWL '98). In China, there have been no accurate assessments of the musk deer population size and musk resources at a national level, but in some provinces some reasonably accurate counts are available (Wang et al., 1993; Yang et al., 1989; Sheng, 1992). For a long time, the musk deer has been harvested for its musk, secreted by the

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musk gland of male, which is one of the oldest raw materials used in the perfumery industry, because of its fixative and scent properties. Musk is one of the most valuable of all animal scents, even more expensive than gold (Green, 1986). Owing to its expense, steep population declines have resulted from over-exploitation, and recently the use of musk in the perfumery industry has decreased as it has been partly replaced by synthetic musk (Green, 1986; Homes, 1999). Natural musk has been used as a sedative and as a stimulant to cure a variety of ailments in East Asian countries, especially in China (Homes, 1999), where the effects of musk have been known in Chinese Traditional Medicine (CTM) for several thousand years. It is included in about 300 pharmaceutical preparations in CTM, so the demand for musk for the production of pharmaceuticals is reported to be 500–1000 kg each year in China (Yang and Feng, 1998; Sheng, 1998). It has been very difficult to find suitable natural or synthetic replacement substances to replace musk in CTM until now.

Traditionally, musk deer are hunted with hand-made-guns, traps and dogs in order to obtain the male's musk sac. In the last two decades, poachers have begun to use modern guns and snares and the usual snare consists of a simple iron or steel wire laid in a circle, which is set along the path in an area of known musk deer activity, and tightens when the animal steps on it. In this way, large numbers of males, females and fawns are killed by snares, even though only males in breeding condition have any musk (Yang et al., 1989; Sheng, 1992, 1998; Sheng and Ohtaishi, 1993). With the expansion of snare use, the death rate of musk deer has shot up, and all species have been forced to the edge of extinction. Although over-exploitation has been largely responsible for the decline of the musk deer, habitat destruction has undoubtedly contributed to the reduction of some populations and, in the long term, may be as serious a threat (Green, 1986). Habitat destruction in China has resulted from deforestation and other human disturbance (Sheng, 1992, 1998; Yang and Feng, 1998).

Generally, although there have been many reports on the conservation status and population trends in musk deer in China, most of these have been based on partial data or limited to certain species. It is, therefore, necessary to study the overall distribution, population and conservation of all musk deer species in China, which is of importance to determine the conservation status and establish appropriate strategies. The purpose of this paper is to present an overall, recent quantitative assessment of the known distribution of the musk deer in China, and to evaluate the extent of the trade in musk and the habitat destruction in order to assess the present status of the populations, based on which, we discuss the conservation measures for the musk deer in China.

2. Methods

We collected data on the historical musk trade from local departments of the Company of Chinese Traditional Medicine (CCTM), statistical bureaux and forestry bureaux in 11 provinces, and analyzed the historical trends in the domestic musk trade, extending the previous analysis for musk production in Anhui, He'nan and Guangxi (Sheng, 1992). Before the middle 1980s, only a small amount of smuggling existed in China; harvested musk were nearly all traded in domestic markets, mainly trade-offs via a local CCTM company, so the data collected from local CCTMs and the provincial statistical bureaux of the range areas should by reasonably representative of the true domestic trade situation. Additional data on international trade with Japan during past decades has been analyzed by Sheng (1992). Once the amounts of musk in domestic and international trade is estimated, it is possible to estimate the numbers of musk deer culled (Green, 1986; Jackson, 1979). To make this calculation, we assumed that: (1) the weight of musk in one musk gland: = 15 g (Yang and Feng, 1998); the number of musk deer killed was calculated on the basis that it required three animals killed to obtain one male musk deer with a sufficiently large musk gland (Green, 1986; Jackson, 1979).

Information concerning the distribution and status of the musk deer in China was obtained by reviewing the literature, and on-site visiting to special areas. In addition, we used line transects to count pellets density and hence estimate the density of musk deer (Yang et al., 1989; Wang and Sheng, 1988). This was done in Changdu in Xizang (Tibet), Baiyu County and Tangjiahe National Natural Reserve in Sichuan Province.

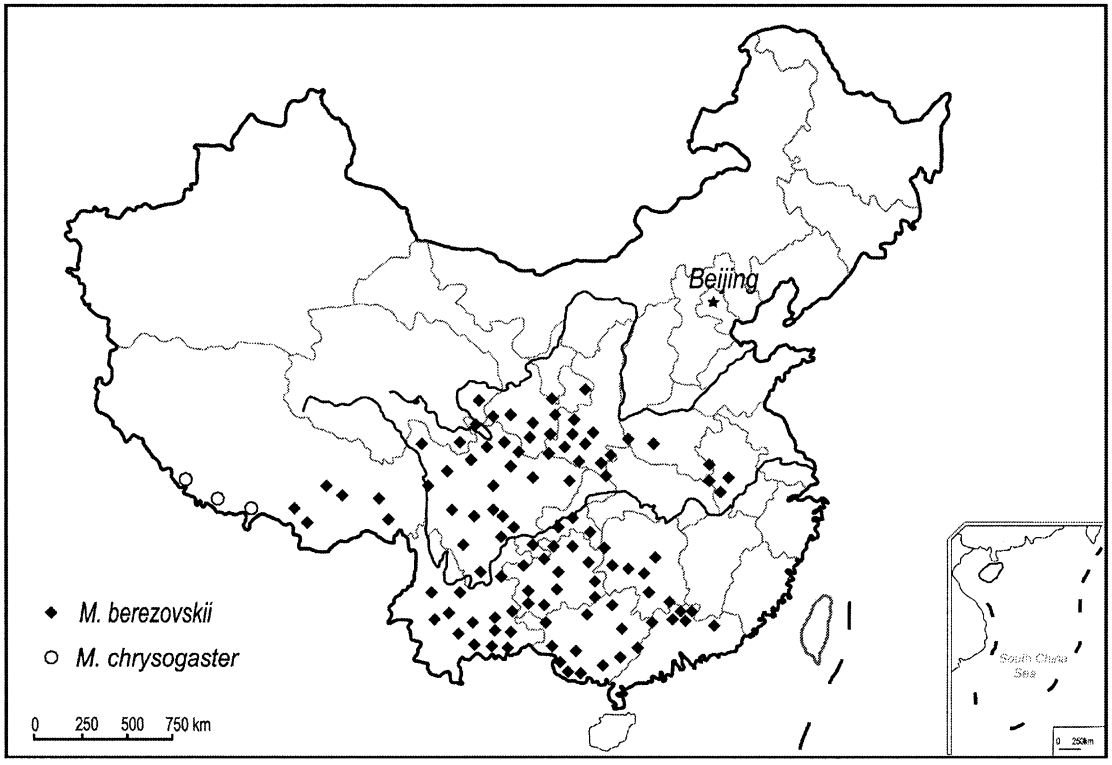
We synthesized all available data to estimate the wild musk deer population in these areas and extrapolated to estimate Chinese populations.

3. Results

3.1. Distribution and population in the wild

In China, the distribution of musk deer extends through most of the forested alpine or sub-alpine zones (Fig. 1). At the geographical scale there is considerable overlap between some of the species, but often the distribution of each species between habitats differs. The Siberian Musk Deer *M. moschiferus* is distributed in northern China, mainly in Hebei Province, Mt. Wutai of Shanxi Province, Mt. Daxing'anling, Mt. Xiaoxinganling, Mt. Changbai, Mt. Zhangguangchailing and Mt. Laoyueling in northeastern China (Ma, 1986). This species was plentiful in the forested regions of northern

(a)



(b)

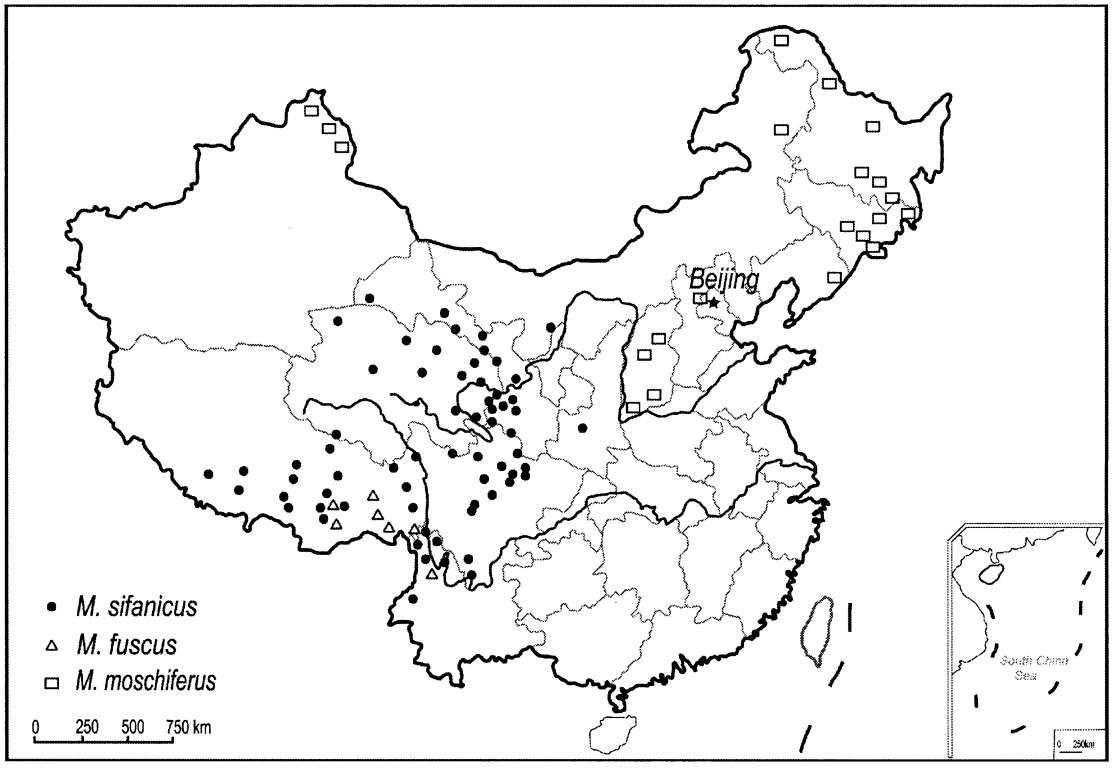


Fig. 1. Current distribution of musk deer in China: (a) *Moschus berezovskii* and *M. chrysogaster*, and (b) *Moschus moschiferus*, *M. sifanicus* and *M. fuscus*.

China in 1950–1960s (Sheng, 1998). Field surveys showed that the population was near 20,000 in Daxing'anling and adjacent regions in the early 1980s, but later the number declined due to the great forest fire of 1987 (Ma, 1986; Sheng, 1998). Now, there has been a decline and there are less than 20,000 musk deer in the entire northeast of China (including Jilin, Inner Mongolia, Liaoning and Heilongjiang). Although Siberian musk deer were distributed historically in other provinces such as Shanxi and Hebei, the population has recently been reported to be on the edge of extinction owing to over-harvesting (Sheng, 1998).

The Forest musk deer *M. berezovskii* is distributed from Ningxia in the north to Guangxi in the south, from Anhui in the east to Xizang in the west. Its distribution regions include Sichuan, Yunnan, Guizhou, Xizang (Tibet), Qinghai, Gansu, Shanxi, Shaanxi, Anhui, Ningxia, Hubei, Hunan and Guangxi Province (Yang and Feng, 1998; Sheng, 1998). Although the Anhui population has recently been shown to belong to a separate species, M. anhuiensis (Su et al., 2001), the geographic boundaries of the two species are unclear, and for the moment we continue to include Anhui musk deer in the Forest musk deer total. Sheng (1998) estimated there were more than one million forest musk deer in 1960s based on the quantity of purchased musk, while only 600,000 were found in the late 1970s. This was due to over-exploitation, which increased in the 1980s, when the price of musk soared, and harvesting became more intensive, with the result that the population of Forest musk deer declined sharply to 200,000–300,000, and to even less than 100,000–200,000 currently (Sheng, 1998).

The Alpine Musk Deer *M. sifanicus* is an endemic species of the Qinghai-Xizang Plateau, mainly scattered in plateau and mountainous regions in western China, including Xizang, Qinghai, western Sichuan, northwestern Yunnan, Ningxia and Xinjiang; it has been historically abundant in such ethnic minority regions as Qinghai, Xizang and northwestern Sichuan (Sheng, 1992; Yang and Feng, 1998). According to the survey conducted by the CCTM in 1961, there were about 180,000 alpine musk deer in Qinghai Province in the 1960s, but only 30,000 were found in the 1970s (Yang and Feng, 1998). Sheng (1998) estimated the population in Xinglongshan National Nature Reserve in Gansu Province and reported that the number stood at 4000–5000 with a density of 23–51 km^{-2} at the beginning of 1990s, but Kang (personal communication) counted again in the same region in the later 1990s and found that the population had declined to only 1000. The above trends of this isolated population indicated that the population of the species as a whole has certainly been declining. Now the total population of alpine musk deer is no more than 100,000 (Sheng, 1998).

The Black Musk Deer *M. fuscus* was the last species of musk deer to be discovered and named in China; it is confined to western Yunnan and southeastern Xizang including the Mt. Gaoligong, Bijiang, Chayu and Motuo, Milin, etc. (Yang and Feng, 1998; Sheng, 1998). Its distribution is very narrow and limited, and the population size is unknown, but it is estimated to be rare and on the edge of extinction.

The Himalayan Musk Deer *M. chrysogaster* is closely related or possibly identical to *M. sifanicus*, it is restricted to the Himalayan regions; in China, it occurs only on the slopes of Himalayas in Xizang (Yang and Feng, 1998; Sheng, 1998), in low numbers because of its narrow distribution.

In summary, the overall range of the musk deer in China has somewhat changed during recent decades, and has become more narrow, scattered and isolated. There are 100,000–200,000 Forest musk deer, 100,000 Alpine musk deer (Sheng, 1992) and 2000 Siberian musk deer (Ma, 1986; Sheng, 1998). As far Black musk deer and Himalayan musk deer are concerned, although their populations remain unknown we can be estimate them as probably low, because of their narrow and limited distributions and low density. The present-day wild population of musk deer in China is estimated to be between 220,000 and 320,000. Clearly, there is a large uncertainty in this estimate, but the evidence shows a marked decline with some species at risk.

3.2. The farming of musk deer and the captive population

In China, the farming of musk deer started in 1958 to produce valuable musk but at the same time preserving the wild populations; and since then there have been efforts made to expand musk deer farming. Many Communal farms and State farms were established, and in the early 1980s the farming population increased so quickly that the number of farmed musk deer reached a peak of ca. 3000 (Zhou et al., 2000). The main species farmed was forest musk deer (including Anhui musk deer), although a few alpine musk deer were maintained in some of them: the other three species were not domesticated (Zhang, 1979). Musk deer are difficult to manage and breed on farms because of their solitary habits, territorial behavior and excitable nature. Thus, many of these enterprises were not successful (Sheng, 1998), and now, there are only a few farms (or Breeding Centers) which continue to successfully raise musk deer (Table 1). Of these, the musk deer farm in Dujiangyan in Sichuan Province holds the largest Forest musk deer captive population ca. 1300 animals. In addition, the Xinglongshan Breeding Center established in 1990 holds ca. 250 Alpine musk deer at present. Adding up the accessible data, at present ca. 1,900 animals are kept in different farms in China (Table 1).

Table 1
The population of captive musk deer in China

Location of farm	Farmed species	Population	Authority
Shanghang, Fujian	*M. berezovskii; M. sifanicus*	20	Visiting
Xinglongshan, Gansu	*M. Sifanicus*	250	Visiting
Zhengping, Shaanxi	*M. berezovskii*	130–150	Zhou, 2000
Foziling, Anhui	*M. berezovskii* (*anhuiensis*)	50–60	Zhou, 2000
Chongming, Shanghai	*M. berezovskii; M. sifanicus*	230–240	Zhou, 2000
Dujiangyan, Sichuan	*M. berezovskii; M. sifanicus*	1200–1300	
Miyaluo, Sichuan	*M. berezovskii*	Closed down	Zhou, 2000
Maerkang, Sichuan	*M. berezovskii*	Closed down	
Mentougou, Beijing	*M. berezovskii*; *M. sifanicus*; *M. moschiferus*	30	Visiting
Heilongjiang	*M. moschiferus*	Closed down	Zhou, 2000
Tiane, Guangxi	*M. berezovskii*	data unaccessible	Xu, 2000

3.3. Threats to musk deer from exploitation

There are many threats to populations of musk deer, of which two are most important: the first is hunting to obtain musk (Wemmer, 1998; Green, 1986; Jackson, 1979), which can be estimated by the trade in musk products (Green, 1986; Homes, 1999), and the loss of habitat (Yang et al., 1989; Yang and Feng, 1998).

3.3.1. Domestic trade in raw musk

Musk trade have occurred historically throughout China via local CCTMs, but are mainly limited to particular provinces. The historical trade in different provinces is listed as follows:

Sichuan Province has been most notable for its abundant deer population and the greatest musk production in China. Here musk deer mainly occur in the alpine or sub-alpine regions surrounding the Sichuan Plains, including Ganzi, Liangshan, Aba, Guangyuan, and Daxian. In the 1950s, the musk exported from China was derived mainly from Sichuan, and musk production in this province accounted for above 80% of domestic trade. From 1952 to 1982, the musk production was stable, at an annual trade of 786 ± 205 kg ($n = 31$) of musk (Fig. 2 a); in the peak year (1954) the production was more than 1200 kg, and even in the lowest years production reached 360 kg (Sheng, 1998). These data showed that the output of musk fluctuated over a 12-year cycle. After the 1980s, the population began to decline due to over-harvesting. From 1982 to 1993, the annual musk output was only 339 ± 156 kg ($n = 11$).

In Yunnan Province, 80% of the musk is harvested from the musk deer population in Diqing Tibetan Autonomous Prefecture, and the rest is sourced from Lijiang, Dali, Baoshan, Zhaotong and Wenshan. At the provincial level, 152 ± 65 kg ($n = 36$) of musk was annually harvested before 1986 in Yunnan, reaching 275.7 kg in 1965. In 1986, owing to the high price of musk, musk deer were killed in enormous numbers, and the musk output once reached 341.2 kg. From then on, musk production has stayed at a lower level and appears to be unstable, but only 38 ± 41 kg ($n = 4$) of musk is harvested annually (Fig. 2a).

In Guizhou Province, which is located in the region between the Yunnan-Guizhou Plateau, Sichuan Basin, and Mt. Hunduan, there is an abundance of vegetation which provides musk deer with good diversity of habitat. The musk production in this province was of importance to overall musk trade in China (Fig. 2a).

In Hubei Province, musk production was high the 1960s and 1970s, third behind Sichuan and Shaanxi Province, but the output was reduced the 1980s as a consequence of increased musk production in Tibet. Although the trend appeared to be increasing (Fig. 2b), musk can rarely be purchased in local CCTM.

In Shaanxi Province there are only the forest musk deer present, mainly in Qinling mountains, Bashan mountains, and Longshan mountains. In Shaanxi, musk was chiefly collected from 30 counties (cities) including Ankang, Hanzhong, Baoji and Shangluo, in all of which the density of human population was very high, so human activity, especially in the "Great Leap Forward" in the 1960s and 1970s, exerted a great influence upon the musk deer population, and so upon musk production. The historical productivity of musk in Shaanxi is shown in Fig. 2b.

In Gansu Province only musk deer, Forest and Alpine musk deer occur, mainly in alpine regions, for example, Mt. Qilian and Mt. Helan. The collected data on the musk trades in Gansu was incomplete due to historical changes in the harvesting companies. From 1973 to 1982, average annual musk production was 48 ± 16 kg ($n = 10$). In 1988, only 0.1 kg musk was traded in the LDCCTM. The decline of musk production is partially owing to the decline of musk deer, partially to the unreported illegal trade and incomplete data recorded in the local CCTM.

In Anhui Province, the output in 1957 was 31 kg, which was equivalent to 6200 musk deer killed (Sheng, 1998). But the production decreased to 2 kg in 1967. In 1977, the distribution was reduced by up to 60% of that in 1957, and the musk deer (mainly *M. anhuiensis*) was

on the edge of extinction, so musk output neared zero. In recent years, the conservation of musk deer was improved in this province, and the population began increasing, although it is still estimated to be less than 1000 (Sheng, 1998).

In Henan Province, musk deer occurred mainly in Funiu mountainous regions but were not plentiful. During the period from 1963 to 1965, the annual musk output was above 30 kg, but it was less than 10 kg in the 1970s. In the 1980s, the hunting of musk deer increased because of the high price, and the peak annual output once reached 60 kg but decreased again later. The musk deer is very rare in this province at present.

In the Guangxi Zhuang Autonomous Region Musk deer were distributed throughout most of this province except for Yulin and Qinzhou. In the 1950s, musk production stood between 30 and 60 kg, but this decreased after the 1970s (Yang and Feng, 1998).

Qinghai Province is one of the main range areas of the Alpine musk deer. In the 1960s, average annual musk production was near 104.15 ± 37.33kg ($n = 10$; Fig. 2b), and the peak production reached near 150 kg. After

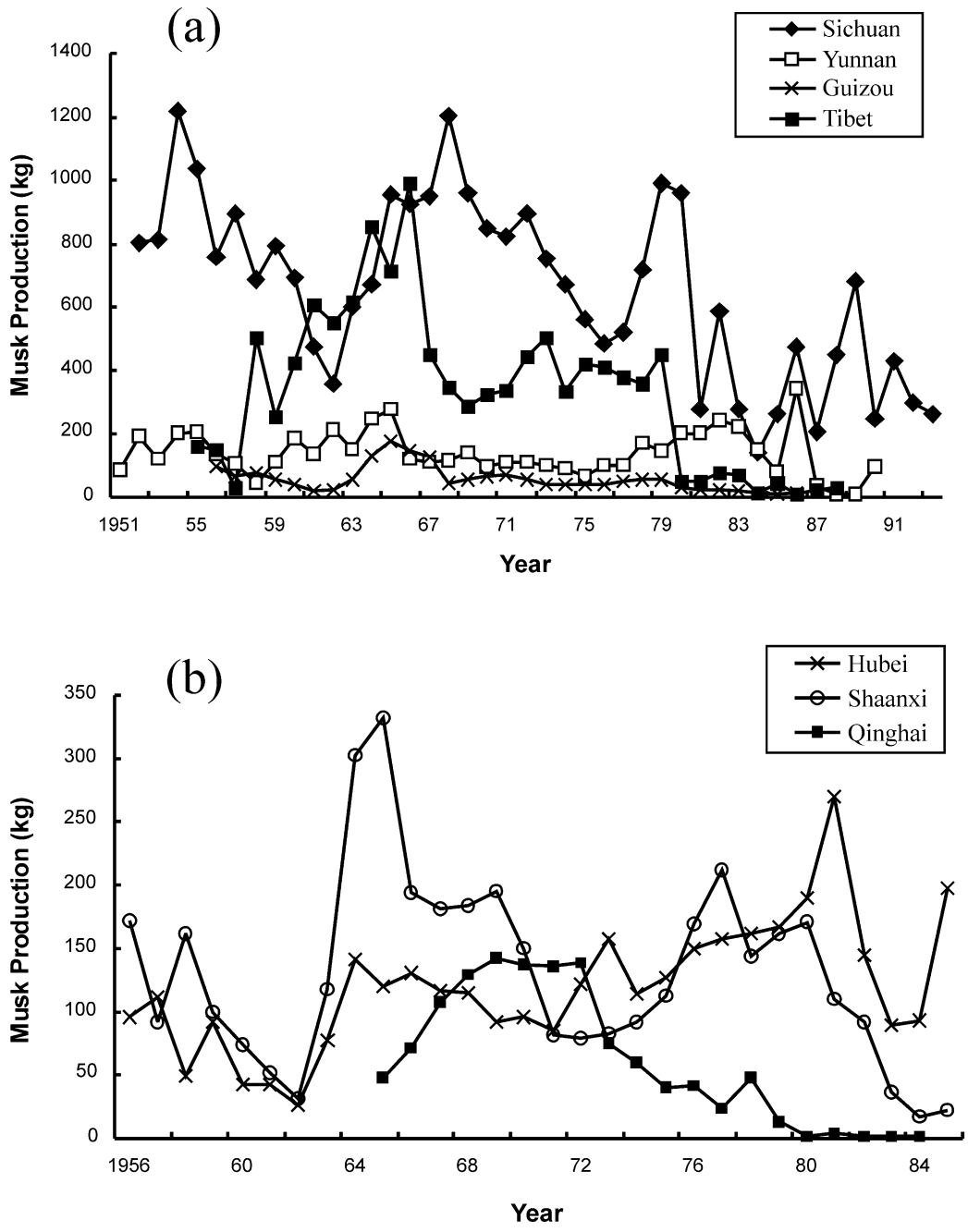


Fig. 2. Historical musk production in selected areas of China: (a) Sichuan, Yunnan, Guizou and Tibet Autonomous Region. (b) Hubei, Shaaxi and Qinghai.

1975, the musk output continued to decrease so precipitately that the average annual output in 1975–1984 was only one fifth of that in the previous decade (17.57 ± 19.13 kg, $n = 10$). There has not been any musk harvested in the local CCTMs since 1985.

The Xizang Tibetan Autonomous Region is the main region making up the Qinghai-Xizang plateau, which is characterized by its high altitude (mean >4000 m), broad plains, sparse humans population, and its diverse habitats. Four musk deer species are still abundant in Xizang, especially in the southeastern and southwestern regions, where there was abundant vegetation of high quality for musk deer. According to the collected data, in 1950s, there was 221 ± 178kg ($n = 5$) of musk annually harvested in Xizang (Fig. 2a), 584 ± 221kg ($n = 10$) in the 1960s and 397 ± 59kg ($n = 10$) in the 1970s. In the 1980s, the production decreased to 42 ± 23kg ($n = 9$).

In conclusion, the historical level of domestic trade of musk in China was high; it originated from wild musk deer culls which were collected via local CCTMs. The number of musk deer hunted for musk (Fig. 3, Green, 1986; Yang and Feng, 1998) shows a marked decline of the musk deer numbers between 1955 and 1988. Moreover, the mass of harvested musk pods harvested between 1961 and 1993 (Fig. 4), show a marked reduction, especially after 1980. This implies that the age of the deer killed reduced, as exploitation reduced the number of older males. A similar correlation between the weight of male pods and age was reported by Zheng and Pi (1984).

3.3.2. International trade in raw musk and derivatives

Japan was always the largest importer of musk, accounting for 85% of global trade, so the figs. for Japanese imports can be used as a barometer of the international musk trade (Green, 1986). About 275 kg of musk were imported annually into Japan during the period from 1974 to 1983 (Green, 1986). Before the 1970s, Japan imported raw musk mainly from India and Nepal, but in the 1980s, when both India and Nepal restricted the international trade of raw musk, Japan imported raw musk from China via Hong Kong (Homes, 1999). According to official Japanese trade figures (cited in Green, 1986), an average 300 kg of raw musk was imported into Japan from China annually (Fig. 5), the peak quantity reaching 500 kg. China does not show up as a major trade of raw musk in the international market, but it was said to be the biggest exporter of musk derivatives, and the main consumers of musk derivative were Asian countries (Homes, 1999). However, it is impossible to quantify the exported musk derivatives in China for lack of data.

3.4. Threats to musk deer through habitat loss and degradation

Musk deer inhabit forested mountainous regions, and nearly all the activities of *M. berezovskii*, *M. anhuiensis*, *M. fuscus*, *M. chrysogaster* and *M. moschiferus* occur in forest. Although *M. sifanicus* can occur in alpine grassland, it does not inhabit pure grassland but around the grass-alpine scrub boundary (Yang and Feng, 1998). Deforestation causing forest fragmentation is a severe threat to the musk deer's long-term survival. Forest fragmentation not only restricts the available habitats, but weakens the viability of isolated meta-populations (Green, 1986; Kirkpatrick, 1995).

For a long time, annual forest felling was much greater than the annual forest re-planting in China: the annual felling of forest was 2.9×10^8 m^3, which was 1.5 times the annual forest re-plant. As an example of the changing scale in the late 1950s in Sichuan province the cut timber stock was ca. 909,000 m^3 per year, but by 1980s there were 121 forestry enterprises with annual stocks of cut timber of between 361,000 and 550,000 m^3 (Li and Yang, 1990). In the Aba prefecture of Sichuan,

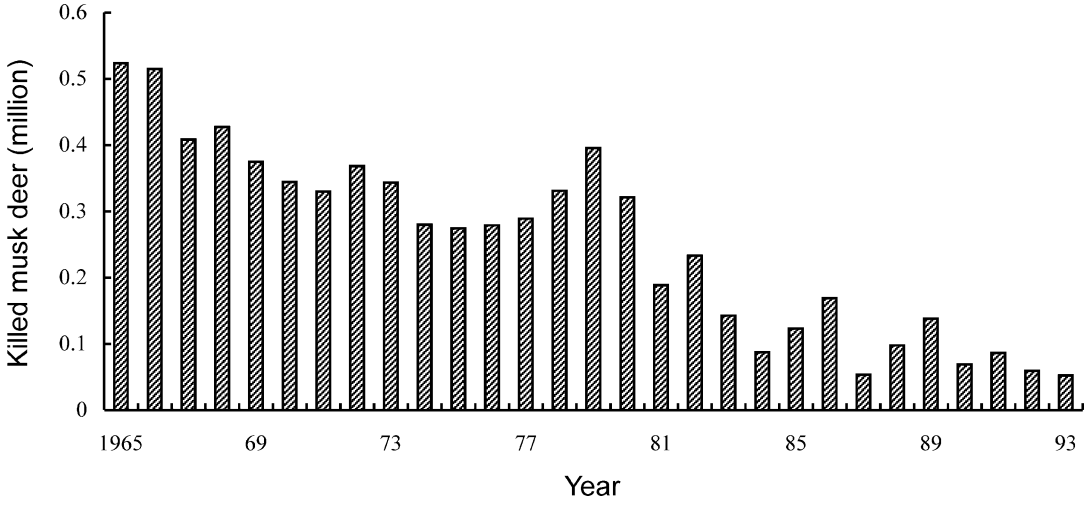


Fig. 3. The annual trend in numbers of musk deer killed annually for musk in China.

200 million m^3 of forest resources were felled during last 25 years, which accounts for 59% of the total forest growth and an annual forest removal four times greater than the annual forest production. In Ganzi prefecture, 120 million m^3 of forest were felled over 30 years, which constitutes 10% of the current forest growth.

However, the situation is improving gradually. In 1998, the Chinese government announced the permanent cessation of deforestation and all staff of forestry enterprises will move towards an afforestation policy in the future. This positive step will improve the prospects for musk deer survival over its entire range.

As well as deforestation, forest fires may have a substantial impact upon musk deer populations, by degrading their habitats. As stated earlier, the musk deer population in Daxing'anling declined steeply owing to a great forest fire in 1987 (Ma, 1986; Sheng, 1998). In 1989 in Baiyu County in the northern Hengduan Mountains of Sichuan Province, musk deer density in mixed forests was 9.15/km^2, while in a region that was recognized as a holy area where hunting was banned entirely, but had been burned deliberately by the local population, the density was only 5.8/km^2.

Furthermore, musk deer habitat degradation also results from agricultural or animal husbandry activities (Yang and Feng, 1998; Sheng, 1992). These human activities can impose disturbance to musk deer, and the domestic herds can compete the food and land with musk deer, and so can affect the musk deer's normal activity such as seasonal migration (Yang and Feng, 1998). In 1994, we surveyed deer populations in the Changdu area of Xizang, and found that nomadic husbandry practices play a key role in influencing the seasonal migrations of Alpine Musk Deer (Fig. 6).

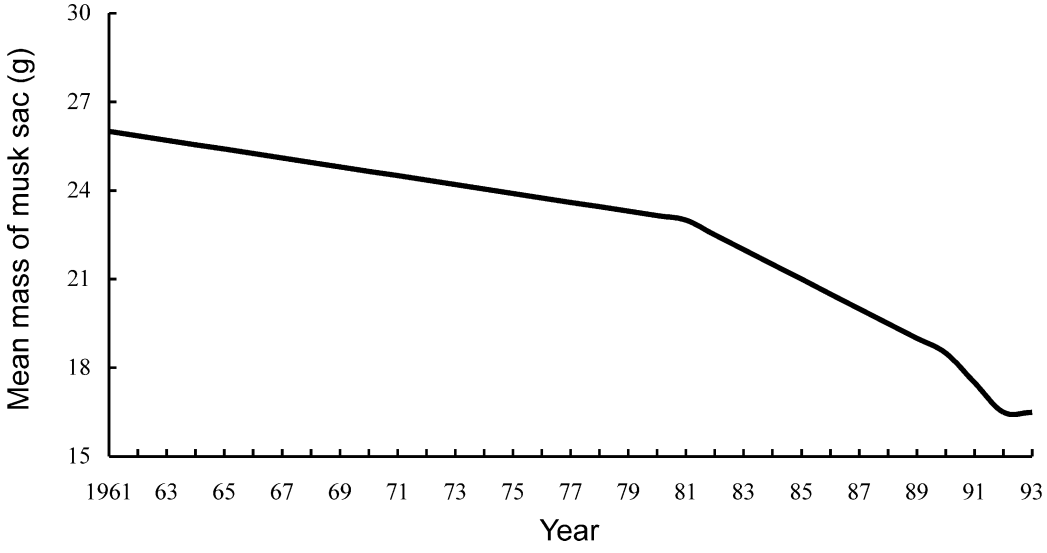


Fig. 4. The annual trend in mass of harvested musk sacs in Tibet.

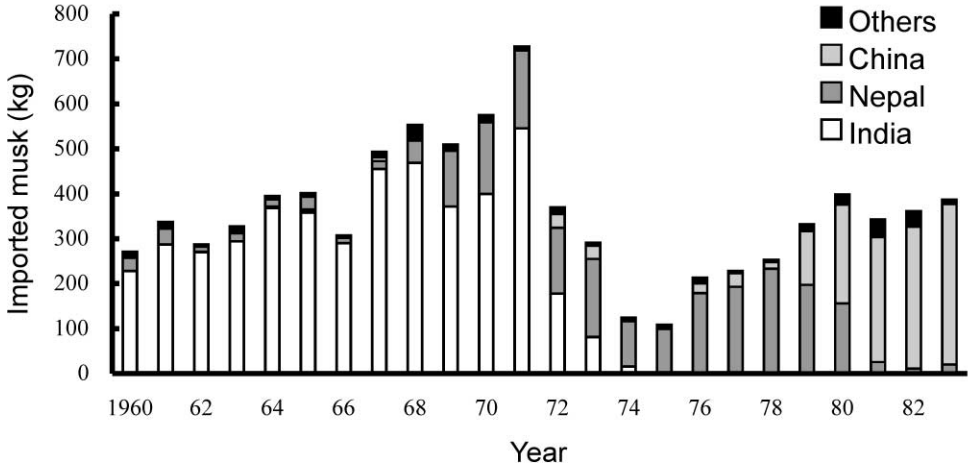


Fig. 5. The amount of musk imported into Japan each year from different countries (1960–1983).

3.5. Conservation

3.5.1. Conservation measures adopted

At the international level, trade in musk is controlled through the Convention on International Trade in Endangered Species of Fauna and Flora (CITES). The aim of the convention is to establish worldwide controls over trade in endangered wildlife and their products, in recognition of the fact that unrestricted commercial exploitation is one of the major threats to the survival of species. All musk deer species in China are included in Appendix II of CITES, so trade in musk is permitted but subject to strict regulation to avoid utilization at a level that is incompatible with survival.

The Chinese government now pays much more attention to wildlife protection. It has launched a series of laws and regulations to preserve rare animals and their habitats, such as the Wildlife Protection Law, the Forestry Law and the Environmental Protection Law and so forth. The enacted laws protect musk deer populations to a certain extent. In addition, all five hitherto recognized musk deer species are classed as second category of the CSKPWL '98, which means that they cannot be caught or hunted without permission from duly delegated authorities. Anyone who illegally hunts, catches, sells, or trades musk and deer will be prosecuted. Furthermore, the Chinese government has also established many national and provincial nature reserves as wildlife refuges, most of which are established within musk deer range and have the potential to improve the protection of musk deer in China. For example, in 1989, we surveyed in Ganzi Tibetan Autonomous Prefecture in northwestern Sichuan Province, which is located adjacent to Xizang Tibetan Autonomous Region and the Hengduan mountains where musk deer were abundant. In the habitat of shrub and mixed coniferous forest, the density of forest musk deer reached ca. 9 animals km^{-2}. When we resurveyed in July 1994, we found that the musk deer had been nearly exterminated, even in the regions where they had been abundant years before. However, in Tangjiahe National Nature Reserve, field investigation was carried out by Wang et al. in 1988 and the reported density of musk deer was 10 animals km^{-2} (Wang and Sheng., 1988). We surveyed the same region, employing the same methods in 1994 and our results showed that the population appeared to be relatively stable over 7 years in the nature reserve, with a density of $9/km^2$. This suggests that the established nature reserves have played an important role in the protection of the musk deer.

3.5.2. Outline for future conservation

In the future, the protection of musk deer in China should be further improved by enforcing the legislation on international trade in musk, and especially tackling the smuggling trade. The domestic demand for CTM should be investigated and assessed rigorously, while research on musk substitutes for use in CTM and the perfumes industry needs to be encouraged and intensified. Clear product labeling of medicinal and perfumes containing natural musk is necessary, and accompanying Chinese official permits should be brought into use.

In situ protection of different musk deer species should be strengthened, particularly for threatened populations, such as the Himalayan musk deer and Black musk deer. Non-sustainable timber harvesting of forests in the range area should be restricted. To conserve the populations of musk deer, the smuggling of musk and poaching of musk deer should be banned entirely. More nature reserves for musk deer should be established to protect a greater proportion of musk deer habitat and of the population. In the currently established reserves, the management of musk deer should be enhanced. Furthermore, in the range provinces, reliable field assessments should be carried out, on the basis of which a scientific management plan should be developed and then implemented. In some regions, experimental study of the sustainable use of musk should be

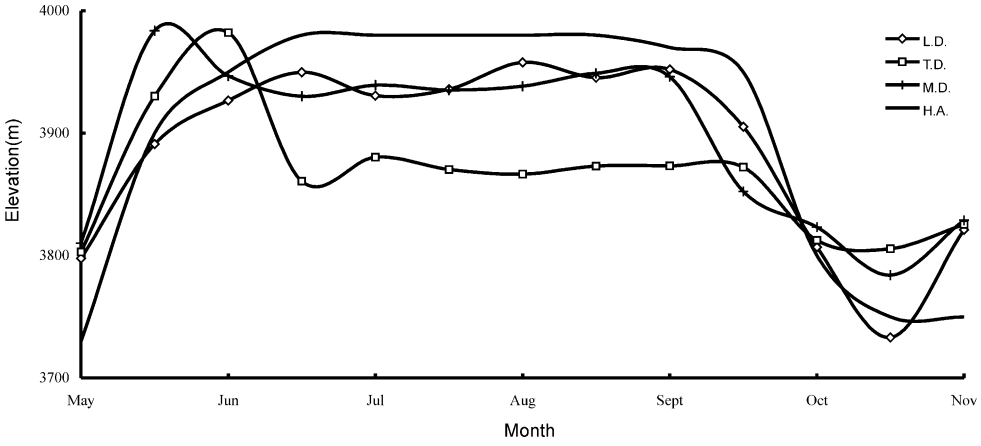


Fig. 6. The distribution of alpine musk deer activity and human activity in Tibet according to the degree of human disturbance: L.D., little human disturbance; M.D., medium human disturbance; T.D., intense human disturbance; H.A., human activity height.

strengthened, including extracting musk from live animals in the wild, by which the income of people in the rural areas can be improved, so that the protection of musk deer populations and their habitats can be effective, and smuggling and poaching should be decreased significantly.

In some areas where the musk deer has become extinct or endangered, and for those species with low population such as *M. fuscus* and *M. chrysogaster*, ex situ protection can be considered as an additional conservation measure, where a captive breeding program is set up, for where animals bred in captivity can be reintroduced into their former range areas. But, international and national cooperation is needed to put this captive breeding program in place. An exchange of scientific and practical information relating to the management and breeding of musk deer on farms should be set up between the countries who are likely to be involved, including China India and Russia. At the national level within China, the present policy of musk deer farming needs to be reviewed, and an economic and species-appropriate management should be developed, based on animal welfare. Farm operators should share information with interested parties and cooperate with scientists to study and improve the farming and breeding of musk deer.

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