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Low Population Density of the Endangered Forest Musk Deer, *Moschus berezovskii*, in China

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Abstract.- Population estimation is important in conservation biology. Conservation projects are generally implemented on the basis of population estimation of objective animals. The Chinese forest musk deer (*Moschus berezovskii*) is an endangered mammal that dwells in the alpine forests. At present, it only exists in fragmented habitats in southwest China. There are currently no population estimates of the wild population of Chinese forest musk deer; therefore, we used distance sampling method and strip transect method to determine the relative population density quantified by the indices of abundance of this species. The results showed that the indices of abundance of the Chinese forest musk deer was 0.16 – 0.24 individuals/km^2 evaluated by using the distance method; and 0.11 ± 0.21 individuals/km^2 evaluated by using the strip transect method. Our results suggested the indices of abundance varies according to the geographical variation, which may attribute to the economic imbalance between eastern part and western in China. In addition, many human disturbances were present in the habitat of Chinese forest musk deer. Extensive poaching was currently being practiced, as revealed by our field observation of 0.14 snares/km^2. In addition, the population trend in Mayuhe and Yele seemed to be decreasing. Consequently, we can postulate that the Chinese forest musk deer had a small population density, and this finding could be attributed to the markedly high human disturbances, particularly poaching, in the habitat of forest musk deer.

Keywords: Pellet groups, distance sampling, human disturbances, line transect, poaching

INTRODUCTION

Population estimation is important in the field of conservation biology and is used to evaluate the outcomes of a conservation project (IUCN, 2013). Information regarding population status of endangered species is considered essential for developing further conservation strategies.

Distancing sampling is a popular method to evaluate population density in recent years. It is based on the detection probability of samples detection to correct the sample value when we miss some samples in the field work (Buckland *et al.*, 2001). The precision of distance sample method is based on three essential assumptions: (i) all samples on the line are detected; (ii) the detected samples are assumed to be motionless before detection (iii) measurements are exact (Buckland *et al.*, 2001). Many studies use distance sampling method to evaluate population density, for instance, red jungle fowl (Subhani *et al.*, 2010), Bornean elephant (Alfred *et al.*, 2010), Asian elephant (Kumara *et al.*, 2012), Przewalski's gazelle (Li *et al.*, 2012) and some large herbivores (Jathanna *et al*, 2003). Distance sampling method is demonstrated to be a reliable technique to evaluate population density (Bården and Fox, 2006; Wegge and Storaas, 2009).

The Chinese forest musk deer (*Moschus berezovskii*), a medium-sized mammal, dwells in alpine forests having an altitude ranging from 2,000 m to 3,800 m (Smith and Xie, 2008). At present, it only exists in some small fragmented habitats in southwest China due to human disturbances (Sheng and Liu, 2007), and is listed as an endangered animal in the International Union for Conservation of Nature (IUCN) Red List of threatened species (IUCN, 2013). It is also included in the Appendices of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (UNEP-WCMC, 2013a). There are five subspecies of Chinese forest musk deer, *M. b. berezovskii*, *M. b. bjiangensis*, *M. b. caobangis*, *M. b. yunguiensis* and *M. b. anhuiensis* (Sheng and Liu, 2007). *M. b. berezovskii* mainly distributed in the province of Sichuan, Qinghai and Tibet; *M. b. bjiangensis* mainly in the northwestern of Yunnan province; *M.*

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b. caobangis mainly in the south of Yunnan province, Guangxi and Guangdong province (Wang and Harris, 2008). The unnamed musk deer in the province of Gansu, Ningxia, Shaanxi, Hubei and Henan listed in IUCN redlist is named as another subspecies of Chinese forest musk deer, the *M. b. anhuiensis* (Sheng and Liu, 2007). The male can produce musk (1 g is worth US $100–$160), and the market demand for musk has been increasing (UNEP-WCMC, 2013b). Frequent poaching to acquire commercial profits threatens this endangered animal (Rao *et al.*, 2010; Sheng and Liu, 2007).

Chinese forest musk deer is disturbed seriously by human activity usually from March to September by digging herbs, grazing and gathering shoots of some plants (Wei *et al.*, 1995; Sheng and Liu, 2007). Chinese forest musk deer defecate randomly when they are under human disturbances although they may have latrines in winter days without human disturbance, and individuals with the same gender would not share home range (Sheng and Liu, 2007). In addition, at close proximity, an observer can distinguish between male and female feces by smell (musk smell in males; foul odor in females; Sheng and Liu, 2007). In recent years, a few reports have investigated the population density of Chinese forest musk deer. Some studies vaguely indicate that this species is near extinction without providing precise data (Peng *et al.*, 2008; Qi *et al.*, 2011). Therefore, by detecting pellet groups in several hotspots, we used distance sampling method and strip transect method to survey the relative population density of Chinese forest musk deer. To evaluate the relative population density absolutely, we surveyed four subspecies of Chinese forest musk deer (*M. b. berezovskii*, *M. b. bjiangensis*, *M. b. yunguiensis* and *M. b. anhuiensis*). We did not survey *M. b. caobangis* for the reason that literature records no Chinese forest musk deer in the south of Yunnan province (Kunming Institute of Zoology, 1999) which is the main distribution area of *M. b. caobangis* in China.

MATERIALS AND METHODS

Study areas

We selected ten sites to estimate the relative population density of the Chinese forest musk deer (Fig. 1, Table I). All areas of the selected sites have been established as nature reserves in the local province or as national nature reserves. The selected sites are mainly covered with coniferous forest, while few sites in low altitude are covered with the mixture of coniferous and broad leaves forests. Most coexisting mammals of Chinese forest musk deer are *Muntiacus reevesi*, *Naemorhedus griseus* and *Capricomis milneedwardsii* (Li, 2010) which are widely distribute in the southwest of China. Generally, the economy in the sample sites of eastern part, CTH, MYH, YL, LZP and GGS is better than that of western part, DLJ, QQ, BZL, KP and GHQ. Chinese forest musk deer in GHQ, KP, BZL, QQ and DLJ is *M. b. bjiangensis*; GGS, LZP and YL the *M. b. berezovskii*; MYH the *M. b. anhuiensis*; CTH the *M. b. yunguiensis*. All selected sites have been historically documented to have an abundance of this species (Yang *et al.*, 2003; Sheng and Liu, 2007, Smith and Xie, 2008), as well as reported by local people as areas where Chinese forest musk deer are frequently sighted. The selected sites were generally designed as planar quadrilateral in relevant nature reserve, and areas of selected sites were calculated using the global positioning system (GPS) navigator.

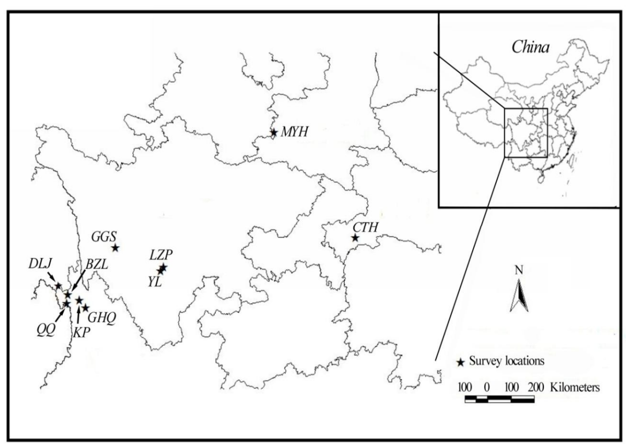

Fig. 1. Selected survey sites for the estimation of forest musk deer population density. Abbreviations of survey locations: GHQ, Gehuaqing; KP, Kangpu; QQ, Qiqi; BZL, Bingzhongluo; DLJ, Dulongjiang; YL, Yele; LZP, Liziping; GGS, Gonggashan; MYH, Mayuhe; CTH, Changtanhe.

Table I.- Survey sites selected in our study.

Survey sites (Central geographic coordinates)[a]	Area (km^2)	Survey time	Altitude (m)	Vegetation types	Institutions (Total area)	Province
GHQ (27.57°N, 99.30°E)	90	April	3,200	Coniferous forest	Baima Snow National N.R. (2,816 km^2)	Yunnan
KP (27.82°N, 99.05°E)	30	April	3,100	Coniferous forest	Baima Snow National N.R. (2,816 km^2)	Yunnan
QQ (27.72°N, 98.57E)	35	May	2,900	Coniferous forest	Gaoligongshan National N.R. (4,015 km^2)	Yunnan
BZL (28.02°N, 98.62°E)	42	May	2,800	Coniferous forest	Gaoligongshan National N.R. (4,015 km^2)	Yunnan
DLJ (27.96°N, 98.33°E)	50	May	2,800	Coniferous forest	Gaoligongshan National N.R. (4,015 km^2)	Yunnan
YL (28.87°N, 102.19°E)	80	June	2,700	Coniferous forest	Yele N.R. (243 km^2)	Sichuan
LZP (30.00°N,102.30°E)	20	June	2,500	Coniferous forest	Liziping N.R. (478 km^2)	Sichuan
GGS (29.68°N, 100.45°E)	24	July	3,100	Coniferous forest	Gonggashan National N. R (4,091 km^2)	Sichuan
MYH (33.75°N, 106.57°E)	108	July	2,300	Broadleaf/coniferous forest	Ziboshan National N.R. (174 km^2)	Shaanxi
CTH (30.03°N, 109.70°E)	15	August	2,000	Broadleaf/coniferous forest	Qizimeishan National N.R. (345 km^2)	Hubei
Total	494					

[a]See Fig. 1.
All surveys were conducted in 2012; N.R., Nature Reserve.

Line transect design

Line transects were established to use a random coordinate as a start point, and a sighting compass was used to establish and maintain the centerline to keep it as straight as possible. And then, a systematically transects were placed with intervals generally 0.3–0.5 km (according to geomorphic variation) to avoid repetitive counting with adjacent ones. Some habitats were the logging area decades ago, and they become secondary forest after logging prohibition (Sheng and Liu, 2007). Therefore, line transects were usually placed respectively in secondary and virgin forest if survey sites were the mixture of secondary and virgin forest. Totally, we placed 54 line transects in all survey areas, 36 in virgin forest and18 in secondary forest. The total line transect distance is 420 km (322 km in virgin forest and 98 in secondary forest). Consequently, 5.4 line transects on average were placed in each survey site. GGS did not have line transects in virgin forest, and GHQ, QQ, DLJ did not have line transects in secondary forest (Table II).

A group of two highly trained observers conducted the field surveys. Each observer individually detected pellet groups on one side of the centerline and exchanged to the opposite side at every 50 m interval along the line transect. Chinese forest musk deer density can change significantly in several weeks under poaching pressure (Yang and Hu, 1989). Therefore, we only recorded fresh pellet groups to evaluate the relative population density of Chinese forest musk deer. Fresh pellets have intestinal tissue on the surface, which has glossy surface or slippery surface by finger.sensation. Pellet groups all have glossy surface regardless of old or fresh pellets in rainy days, so we needed to assure their freshness during rainy days by sensation of slippery surface using fingers. Usually, fresh pellet groups have small peaks on the top, and the approximate diameter of the individual pellet group is less than 20 cm. If pellet groups did not absolutely obey these rules when we surveyed in the field, then we should observe the characters of pellets carefully, including color, humidity of the surface tissue etc. to differentiate pellets that may belong to two groups. Finally, we differentiated pellet groups of males and females with interval of short distance on the basis of odor (Sheng and Liu, 2007) if we can not distinguish them by direct observation. Moreover, group over 40 pellets was recorded as one pellet group (Hemami and Dolman, 2005). In addition, we needed to record the perpendicular distance which is from a pellet group (from the cross between the largest diameter and the shortest diameter) to the centerline using a steel tape. A GPS navigator was used in the surveys to record the length of the line transect (distance along the centerline). Fieldwork was conducted from 09:30 h in the morning to 16:30 h in the afternoon, and observers rested for an hour at noon to obviate fatigue.

Table II. Forest musk deer population density and human disturbances recorded during the surveys.

Survey Locations[a]	Line number		Line length (km)		Population density (per km^2)		Human disturbances (per km^2)		
	V.F.[b]	S.F.[c]	V.F.	S.F.	V.F. (mean±SD)	S.F. (mean ± SD)	Snares[d]	Sheds[e]	Persons[f] (mean ± SD)
GHQ	6	0	42	0	0.34 ± 0.29	0.00 ± 0.00	0.00	0.02	0.82 ± 0.97
KP	3	2	22	12	0.24 ± 0.05	0.00 ± 0.00	0.23	0.03	0.57 ± 0.81
QQ	4	0	24	0	0.00 ± 0.00	0.00 ± 0.00	0.00	0.00	1.43 ± 0.33
BZL	3	2	17	10	0.00 ± 0.00	0.00 ± 0.00	0.71	0.00	0.00 ± 0.00
DLJ	3	0	15	0	0.00 ± 0.00	0.00 ± 0.00	0.04	0.06	4.95 ± 4.76
YL	4	3	41	15	0.39 ± 0.46	0.03 ± 0.06	0.26	0.01	0.00 ± 0.00
LZP	1	3	6	11	0.00 ± 0.00	0.00 ± 0.00	0.00	0.00	0.88 ± 1.03
GGS	0	3	0	18	0.00 ± 0.00	0.00 ± 0.00	0.00	0.00	0.00 ± 0.00
MYH	11	3	151	24	0.06 ± 0.04	0.04 ± 0.04	0.03	0.00	0.00 ± 0.00
CTH	1	2	4	8	0.14 ± 0.00	0.07 ± 0.10	0.13	0.00	0.27 ± 0.46
Mean	3.6	1.8	32.2	9.8	0.11 ± 0.21	0.02 ± 0.04	0.14	0.01	0.78 ± 1.70

[a]See Fig. 1.
[b]Virgin forest.
[c]Secondary forest.
[d]Wire snares used for poaching of Chinese forest musk deer.
[e]The shield used for persons grazing their cattle or gathering herbs in the habitat of the Chinese forest musk deer.
[f]The persons grazing their cattle and gathering herbs or shoots in the habitat of the Chinese forest musk deer.

Human disturbance surveys

Some human disturbances do not distribute randomly in the Chinese forest musk deer habitat. Therefore, we recorded all those human disturbances in the whole sampling sites. Those human disturbances include sheds and the presence of wire snares (Sheng and Liu, 2007). Human usually selected places where there is water or some comfortable platforms to construct shed, so sheds were investigated adjacent to spring water or small platforms in sampling sites. Wire snares were detected in the survey areas by following the tracks of poachers to record them as thoroughly as possible. In addition, strip transect was used to detect human presence (humans other than scientists or forest guards). The width of the strip was set to 0.5 km along with line transects. Footprints and other anthropogenic markers were detected in the range of 100 m. Furthermore, outstanding stone or highland was chosen as platforms to detect the presence of humans in the range of about 150 m by observation or listen for about 10 minutes. The number of persons were inferred on the basis of footprints and recorded as human presence data if no persons were detected in the line transect direction; however, when both footprints and persons were detected, only the number of persons was recorded. If some humans were detected several times during a day, we recorded their presence only once.

We used Mann – Whitney U test to compare the differences of human presence between sampling sites. All statistics were performed by SPSS 16.0 (SPSS, Chicago, Illinois, USA).

Line transect statistical methods

Musk deer (Harris and Cuiquan, 1993; Sheng and Liu, 2007), like some other small related ruminants (Li, 2010; Wegge and Mosand, 2014), are recorded to have the behavior of latrine defecation, and this may bias the results of population density estimation. Besides, we find that the defecation rate of Chinese forest musk deer is too small (Hu *et al.*, 2007; Guo and Hu, 1998; Wang and Sheng, 1988; Wei *et al.*, 1995) compared with other closely related animals from previous studies (Marques *et al.*, 2001; Rogers, 1987). We need further study to ascertain the defecation rate of this species if we want to estimate the absolute population density. Finally, it is difficult to estimate the accurate population density of rare Chinese forest musk deer using distance sampling method (Wegge and Storaas, 2009). Therefore, even if the software distance produces density estimates, we only used these results as indices of abundance (F) to quantify the relative population density of Chinese forest musk deer, which may make our study more logical.

The indices of abundance (ind./km^2) was calculated using the following three variables (Baskaran *et al.*, 2013):

$$F = (Y \times R)/D$$

where Y is the density of pellet groups; R is the decay rate of fresh pellets (the disappearance rate of glossy to non-glossy pellets per day); and D is the defecation rate (pellet group number produced per musk deer per day). Y was estimated using the Distance software package (Thomas *et al.*, 2009). The decay rate of fresh pellets R was considered to be 0.1-0.14 on the basis of the findings of several studies *viz*., Wang and Sheng (1988) in April, Wei *et al.* (1995) and Guo and Hu (1998) in June at YL, Hu *et al.* (2007) in April at MYH. Defecation rate of Chinese forest musk deer is stable (Sheng and Liu, 2007), and studies reported that the defecation rate is 4.61 - 4.91 pellet groups per day in a wild habitat model (Wang and Sheng, 1988; Yang and Hu, 1989).

Only sites with documented pellet groups were selected to estimate the relative population density. Analysis performed using Distance software was conducted by manually setting the distance intervals primarily on the basis of the goodness of fit test to avoid measurement or truncated errors, and several combinations of key detection functions and adjustment terms were used to develop a candidate model (Thomas *et al.*, 2009). Visual inspection of detection probability and probability density plots (qq-plot) were used for model data fitting. The smallest Akaike's information criterion (AIC) value was used to select the best model (Thomas *et al.*, 2009).

Distance sampling analysis depended on the reliability of detection function that can be analyzed even if numerous factors affect the probability of detection object and that has statistical significance (Burnham *et al.*, 1980; Buckland *et al.*, 2001). In addition, our survey sites were mainly covered by coniferous forests, and the same observers used the same method to detect pellet groups. Therefore, we integrated all survey sites of virgin or secondary forest as a single one during the analysis performed using software Distance, given that the detection function is a mixture of many simple functions (Burnham *et al.*, 1980).

Strip transect design and statistical methods

We also surveyed relative population density of Chinese forest musk deer using strip transect method. Surveys using strip transect method were studied simultaneously with surveys with distance sampling method. We fixed the width of strip transect as 30 m (Yang and Hu, 1989) along with the centerline of line transect. Relative population density (F_1, indices of abundance; ind./km^2) of every strip transect was calculated using the formula below:

$$F_1 = (N\times R)/(W\times L\times D)$$

Where N is the number of fresh pellet groups recorded in one strip transect; R is the decay rate of fresh pellets (the disappearance rate of glossy to non-glossy pellets per day; we selected R as 0.12 the mean value of several studies in Wang and Sheng (1988), Wei *et al.* (1995), Guo and Hu (1998) and Hu *et al.* (2007); W is the width of strip transect; L is the length of strip transect; and D is the defecation rate (pellet group number produced per musk deer per day; we selected R as 4.76 the mean value in studies of Wang and Sheng (1988), and Yang and Hu (1989)). Then we compared the differences of relative population density between sampling sites. We also compared the differences of relative population density between virgin forest and secondary forest. All statistics were performed using Spss 16.0 (SPSS, Chicago, Illinois, USA).

RESULTS

Distance sampling

Truncation data were used to evaluate pellet group density of virgin forest on the basis of the goodness of fit test (Fig. 2). Half-normal key functions with cosine adjustments were used to estimate the density by using Distance that considered the minimum AIC, and the effective strip width was 14.81 m. The percent coefficient of variation was 25.06%, and the estimated pellet groups density was 7.82 groups/km^2 (95% confidence interval (CI) = 4.73 – 12.92). Therefore, the indices of abundance of Chinese forest musk deer was 0.16 – 0.24 individuals/km^2.

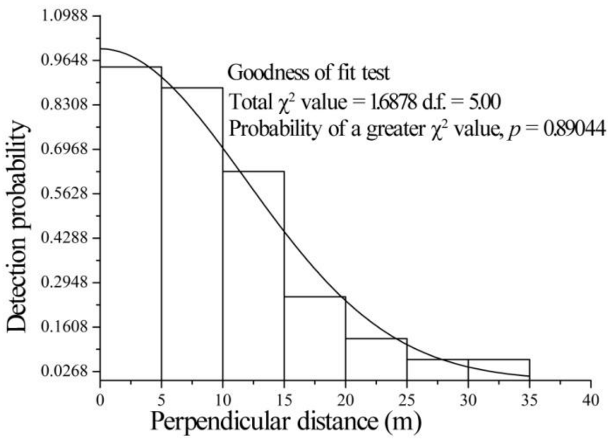

Fig. 2. Estimated detection probability of forest musk deer pellet groups from the distance sample. Data truncated at 35 m (observations = 47).

Strip transect

Moreover, we also recorded small indices of abundance using strip transect method, 0.11 ± 0.21 individuals/km^2 in virgin forest and 0.02 ± 0.04 individuals/km^2 secondary forest (Table II), with several sites showing no record. Pairwise comparison of relative population density between sample sites suggested that the main difference is observed between sample sites MYH and some others (Table III). In addition, QQ and BZL are significantly different from KP, which may attribute to some scientists devoting theirselves to the ecological conservation (indices of abundance in KP > QQ and BZL; personal communication) (Table III).

A markedly higher number of pellet groups was recorded in the virgin forest (0.16 pellet groups per km of the line transect) than in the secondary forest (0.04 pellet groups per km of the line transect) during our surveys. However, we did not find significant difference of relative population density between virgin forest and secondary forest tested by Mann – Whitney test (P > 0.05), which may need much more sample sizes to study this phenomenon in future research.

Human disturbance

Various types of human disturbances were recorded at the survey locations, including the presence of snares, sheds, and humans who gathered herbs, bamboo shoots, or other plants as food (Table II). Our results suggested that many sample sites are under the same extent of heavy pressure in human disturbance (Table III). Moreover, we observed much more human disturbance in QQ and DLJ than MYH.

DISCUSSION

Distance sampling

Due to the fact that small pellet groups were recorded in the secondary forest, we only estimated relative population density of Chinese forest musk in the habitat of virgin forest using distance sampling method. In addition, we only selected some hotspot to survey the abundance of Chinese forest musk deer, so the results in our study were overestimated. The indices abundance in our result was the relative density, but it was not the exact data of population density. However, Our data was so small that we can postulate that Chinese forest musk deer has small population density in its primitive habitat.

Strip transect

Our results suggested that indices of abundance in some sampling sites seems to be declining compared with previous studies. The indices of abundance in MYH in our study (Table II) is lower than the study conducted years ago (Hu *et al.*, 2007; 0.48 individuals/km^2). In addition, the indices of abundance in YL in our study (Table II) is also lower than previous study (Guo and Hu, 1998; 1.43 individuals/km^2). These results may suggest the population status of Chinese forest musk deer is decreasing, which is consistent with the population trend of this species recorded in IUCN (IUCN, 2013).

Our results suggested that the indices of abundance may vary according to the geographical variation, which may attribute to the economy condition difference. We observed the indices of abundance in MYH was significant higher than QQ and DLJ, and we also observed human disturbance in QQ and DLJ was significant higher than MYH (Table III). People in developing area depend on

Table III.- *P* - value of pairwise comparison between sample sites.

	GHQ	KP	QQ	BZL	DLJ	YL	LZP	GGS	MYH	CTH
GHQ	NA	0.548	0.082	0.082	0.167	0.914	0.114	0.167	0.216	0.857
KP	0.662	NA	**0.036***	**0.036***	0.100	0.857	0.057	0.100	**0.005***	0.500
QQ	0.476	0.190	NA	1.000	1.000	0.063	1.000	1.000	**0.009***	0.333
BZL	0.177	0.310	**0.016***	NA	1.000	0.063	1.000	1.000	**0.009***	0.333
DLJ	0.167	0.071	0.400	**0.036***	NA	0.114	1.000	1.000	**0.038***	0.500
YL	0.836	0.639	0.315	0.106	0.183	NA	0.114	0.114	0.138	0.800
LZP	0.914	0.730	0.686	0.286	0.229	0.927	NA	1.000	**0.018***	0.400
GGS	0.262	0.393	0.057	1.000	0.100	0.183	0.400	NA	**0.038***	0.500
MYH	0.091	0.219	**0.001***	1.000	**0.003***	**0.038***	0.158	1.000	NA	0.167
CTH	0.548	0.786	0.057	0.571	0.100	0.517	0.629	0.700	0.432	NA

Top right is pairwise comparison of population density between sample sites.
Left bottom is pairwise comparison of human presence (persons who gathered herbs, bamboo shoots, or other plants as food) between sample sites.
* Significant ($P < 0.05$) for comparison between sample sites. NA, no value.

much more raw materials in the field than the people in developed area (Primack, 2010). We know well that China has much better economic income in the eastern part than that of western. Usually, species extinction or biodiversity loss is closely related to poor economic income (Barrett *et al.*, 2011). Therefore, the indices of abundance of Chinese forest musk deer may change with geographical variation consistent with economic income variation.

Human disturbance

Our results suggested that extensive human disturbances might result in the low relative population density of Chinese forest musk deer, which was consistent with the findings of previous studies suggesting that human disturbances are the fundamental cause for the decline of wildlife (Ogutu *et al.*, 2011). In particular, we found that poaching using wire snares was still practiced, and these snares would slaughter Chinese forest musk deer irrespective of whether they were males, females, or fawns (Yang *et al.*, 2003). A study reported that the density of Chinese forest musk deer decreased from 3.79 to 1.84 individuals/km^2 in 40 days when poachers placed 15 wire snares per km^2 in a field (Yang and Hu, 1989).

Other potential reasons to the small indices of abundance may be predation or habitat degradation. Chinese forest musk deer is vulnerable to predator because of no defensive organ to protect itself or the fawn (Sheng and Liu, 2007). The fawn usually becomes the prey of other predator, such as yellow throated marton (Aryal, 2006), which makes population increase slowly. Moreover, previous logging and continuous human disturbance degraded the habitat, which is another factor that may result in the small indices of abundance (Rybicki and Hanski, 2013).

Conservation issue

Although the in-situ conservation area is increasing after 1980s when we consider conserving Chinese forest musk deer, and a series of laws have been launched many years ago (Sheng and Liu, 2007). However, poaching is still observed in the field work. Poaching problem can not come to an end for the enormous profits from musk trade or smuggling (Challender and MacMillan, 2013). To some extent, the management to Chinese forest musk deer in nature reserve is the war to poaching. Therefore, in the immediate future, we should incentivize and establish capacity within local people to conserve Chinese forest musk deer (Challender and MacMillan, 2013). In the long term, we should find out the substitute of musk (Meng *et al.*, 2012) and then ban the trade of musk in the world absolutely.

Moreover, the widespread prevalence of poverty and economic insecurity make conservation increasingly difficult (Bhagwat, 2012). Economic income of local people largely comes from grazing, gathering herbs *et al.* which mainly damage the habitat of Chinese forest musk deer (Wei *et al.*, 1995). However, the threats to the survival of Chinese forest musk deer are not easy to eliminate because local people obtain great economic profit from grazing, gathering herbs etc. Therefore, we should arrange a program which could generate a self-supporting economy and support wildlife conservation at the grass roots level (Shrestha, 1998).

In summary, we used both distance sampling method and strip transect method to survey the relative population density of Chinese forest musk deer. Although we observed higher indices of abundance using distance sampling method, we can not compare these two survey methods directly for different theoretical basis. However, both results suggested Chinese forest musk deer has small relative population density. To a large extent, small relative population density of Chinese forest musk deer was attributed to the human disturbance, especially poaching. Consequently, we should give much more conservation concern to this species.

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Conflict of interest

The authors have declared no conflicting interests.

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