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Current Status of *Macaca mulatta* in Taihangshan Mountains Area, Jiyuan, Henan, China

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Abstract Primatologists have classified rhesus macaques of the Taihangshan Mountains area as *Macaca mulatta tcheliensis*, a subspecies confined to China. The northernmost area of its distribution is in the southern part of the Taihangshan Mountains, which includes a National Nature Reserve established in 1998. To investigate the current status of the subspecies, we surveyed the population and distribution of macaque groups in Jiyuan, Henan, China. In addition, we investigated habitat preferences and the food items foraged by macaques during winter and early spring. The results show that: 1) *ca.* 2100 macaques currently inhabit the Taihangshan Mountains National Nature Reserve, mainly in Jiyuan; 2) fragmentation of habitats of rhesus macaques have become severe in recent years; and 3) food resources are very poor during the long winter and the early spring. Macaques in the Taihangshan Mountains feed mainly on seeds, twigs, and bark and the eggs of some insects.

Keywords China · habitat · Jiyuan · *Macaca mulatta* · population · Taihangshan mountains

Introduction

Rhesus macaques (*Macaca mulatta*) are widely distributed in China, and *Macaca mulatta tcheliensis* is a subspecies confined to China southern Taihangshan Mountains area (Jiang *et al.* 1991; Zhang *et al.* 1991), near the boundary of Henan

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and Shanxi Provinces. Zhang and Shi's (1993) analyses on mitochondrial DNA (mtDNA) variation in *Macaca mulatta* of China discriminated ≥6 groups, but only 4 are significant: the Hainan group, the Fujian group, the northern (Henan and Shanxi) group, and the rest of Chinese *Macaca mulatta*. Brandon-Jones *et al.* (2004) noted that *Macaca mulatta tcheliensis* is possibly synonymous with *M. m. sanctijohannis*, if not with *M. m. mulatta*. In the most authoritative review to date, Fooden (2000) concluded that no subspecies of *Macaca mulatta* is recognizable. We here adopt Fooden's conclusion and do not discuss the taxonomy of *Macaca mulatta*, referring to the population simply as Taihangshan macaques.

To protect the macaques, the Chinese government established a National Nature Reserve in the Taihangshan Mountains area in 1998. The area is probably in the northernmost occurrence of rhesus macaques in China (Qu *et al.* 1993; Song and Qu 1996; Zhang *et al.* 1989, 1993). Researchers carried out several studies on Taihangshan macaques in the mid-1980s (Qu *et al.* 1989a, 1989b), but with the development of the local economy and fragmentation of habitats, the population and distribution of rhesus macaques in the Taihangshan Mountains area likely changed during the past 2 decades. We assessed the current status of the Taihangshan macaques, with the aim of determining the population and the distribution of existing groups. In addition, a second aim was to investigate the population's habitat preferences and diet during the winter and early spring.

Methods

Study Site

Taihangshan Mountains National Nature Reserve is located in the northern part of Henan province, on the southern slopes of South Taihangshan Mountains (34°54′–35°16′ N and 112°02–112°52′ E). The Reserve covers *ca.* 15,572 ha, bordering the Yellow River in the south, and reaching the boundary of Shanxi Province. Continental and marine wind currents, with a prevalence of a northwest wind in winter and southeast wind in summer, alternately influence the region. The climate is a continental monsoon type. There are 4 distinct seasons, with variation in sunlight, heat, and precipitation simultaneously. The mean annual sunshine is 2367.7 h, with a total solar radiation of 118.17 kcal/cm^2, while the mean temperature is 14.3°C in the plains area, 14.9°C in the foothills along the Southern Taihangshan Mountains, 13.2–14.0°C in the lower hilly area, and 8.6–11.1°C in the mountainous area. The mean annual precipitation is 695 mm, *ca.* 70 mm more than which on the plains area, though precipitation exhibits both temporal and spatial variation. There are 1698 species of vascular plants, belonging to 734 genera and 163 families in the Reserve, most being seed plants (Lü *et al.* 2002; Song and Qu 1996).

Survey

We conducted the survey between November 2004 and March 2005 in the mountainous Jiyuan area, Henan, China, where the majority of Taihangshan macaque populations live. Six teams, with 2–3 observers, searched for groups of

Table 1 Groups and populations of Taihangshan macaques in Taihangshan Mountains area

Site	Group	Total	Adult males	Adult females	Subadults	Juveniles and infants	Singles
Huanglianshu	Douding	100	10	40	30	20	
Huanglianshu	Beidagou	80	10	35	25	10	
Huanglianshu	Bashimuwa	103	12	40	30	18	3
Huanglianshu	Shuipu	123	15	50	45	10	3
Huanglianshu	Liaowangtai	100	12	40	30	18	
Yugong	Shifangyuan	21	5	4	6	3	3
Manghe	Zhuyugou	65	8	20	27	10	
Manghe	Dawpo	24	7	8	7	1	1
Manghe	Jinzhai	60	5	17	28	10	
Manghe	Zibaigou	68	6	16	37	9	
Manghe	Huanglianshugou	20	2	5	8	5	
Manghe	Shagou	187	19	55	87	26	
Wulongkou	Chouergou	62	11	16	18	10	7
Wulongkou	Houchangda	186	25	56	50	25	30
Wulongkou	Houchangxiao	85	11	30	19	10	15
Wulongkou	xiangchungou	43	8	20	10	5	
Wulongkou	Shoufeizhan	26	4	12	4	6	
Wulongkou	Qugou	32	6	15	7	4	
Shaoyuan	Shaoyuan	0	0	0	0	0	0

macaques in the different areas of the Reserve. Searchers began at about 0600 h, walking slowly and quietly, stopping every 100 m to scan the forest visually and to listen for sounds of macaques. Once we found a macaque group, we counted the number of adults (male and females), subadults, juveniles, and singles as accurately as possible. We recorded the time macaques spent on foraging, rest, drink, and play, and made video and photographic records of the activities. We also recorded the habitat type. We recorded the food resources the macaques used based on observation of leavings, feeding traces, and examination of feces and direct observation of feeding. We continued to observe a macaque group if they moved on to a new area, and once they selected a place to sleep, we stopped observations for that day. In subsequent mornings, before the group became active, we resumed the survey, and continued observations. For each group, we continued observations and tracking for 3–4 days to estimate their active range. To determine macaque

Table 2 Characteristics of main habitat types of Taihangshan macaques

Composition of community	Altitude (m)	Favored degree
Platycladus orientalis + *Ziziyphus j uj uba* + *Vitex negundo*	<800	++
Gleditsia heterophylla + *Cotinus coggyaria* + *Vitex negundo*	<800	++
Quercus variabilis + *Q. aliena* + *Q. dentata*	500–1300	+++
Lespedeza bicolor + *Spiraea* spp. + *Campylotropis acrocarpa*	800–1300	++
Carpinus turczaninowili + *C. baronii* + *Carpinus cordata*	800–1400	+++
Toxicodendron vernicifluum + *Acer mono* + *Euptelea pleiosperma*	1000–1700	++
Pinus armandii + *Q. aliena* var. *acutiserrata* + *Carpi nus cordata*	1300–1700	++
Q. aliena var. *acutiserrata* + *Q. aliena* + *Q. mongolica*	1300–1800	++
Q. mongolica + *Q. liaot ungensis* + *Carpinus cordata*	>1000	++
Pinus armandii + *Q. mongolica* + *P. bungeana*	>1700	++

distribution, we collected broad data: food and feces. Further, we investigated the status of fragmentation within the reserve caused by highways, railways, and roads.

Results

Population and Distribution

There are *ca.* 1400 individuals divided into 18 groups currently inhabiting the Taihangshan Mountains area (Table 1). They are distributed separately throughout the Reserve (Fig. 1).

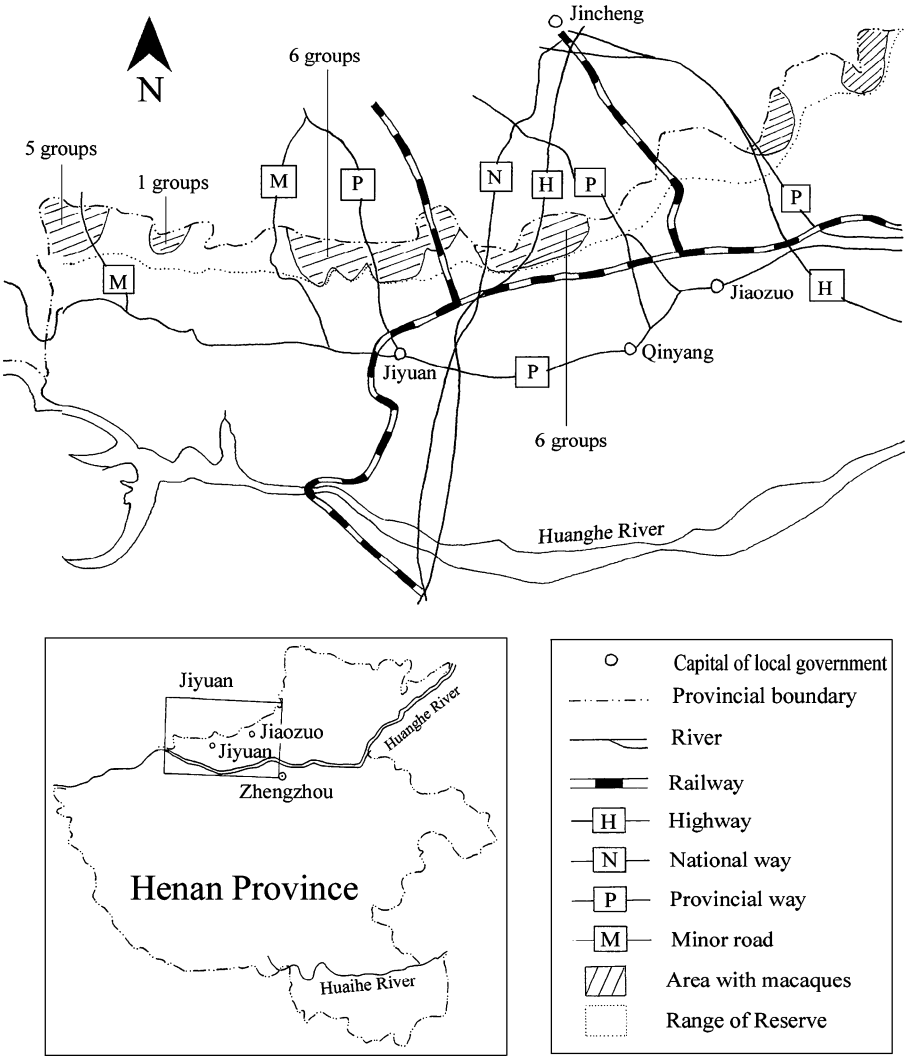

Fig. 1 Distribution and fragmentation pattern of macaques in the Taihangshan Mountains National Nature Reserve.

Table 3 Main plant species Taihangshan macaques utilize in winter and early spring

Species	Seed	Twigs	Bark
Pinus armandii	+		
Celtis bungeana			+
C. koraiensis			+
Pteroceltis tatarinowii		+	+
Ulmus taihangshanesis			+
U. pumila			+
U. laciniate			+
U. davidiana			+
U. parvifolia			+
U. glaucescens			+
U. lamellosa			+
U. bergmanniana			+
Zelkova sinica			+
Z. serrata			+
Hemiptelea davidii			+
Castanea seguinii	+		
C. mollissima	+		
Quercus acutissima	+		
Q. variabilis	+		
Q. aliena	+		
Q. baronii	+		
Q. mongolica	+		
Q. liaotungensis	+		
Q. dentata	+		
Sophora japonica	+		
Indigofera amblyanha	+		
I. kirilowii	+		
I. bungeana	+		
Lespedeza bicolor	+		
L. Formosa	+		
L. dahurica	+		
L. floribunda	+		
L. virgata	+		
L. tomentosa	+		
L. cuneata	+		
L. caraganae	+		
Robinia pseudoacacia	+		
Campylotropis macrocarpa	+		
Vicia unijuga	+		
Pueraria lobata	+		
Pistacia chinensis			+
Rhus chinensis		+	+
Vitex negundo		+	+
Broussonetia papyrifera		+	+
Malus honanesis	+		+
Prunus armeniaca	+		
Diospyros lotus	+		

Habitat

The habitats the macaques utilized include not only natural environment such as original and secondary forest and shrub but also man-made environment. They are distributed mainly among 10 types of habitats (Table 2).

Table 4 Macaques living in the other parts of the Taihangshan Mountains National Nature Reserve

Site	Groups	Population	References
Huixian, Henan	2	110	Zhang *et al.* 2002
Xiuwu, Henan	2	130	Lu *et al.* 1997; Zhang *et al.* 2002
Jiaozuo, Henan	2	60	Zhang *et al.* 2002
Qinyang, Henan	2	110	Zhang *et al.* 2002
Lishan, Shanxi	9	360	Liu *et al.* 2004; Zhang *et al.* 2002

Among the aforementioned habitats (Table 2), *Quercus variabilis* + *Q. aliena* + *Q. dentata* and *Carpinus turczaninowii* + *C. baronii* + *Carpinus cordata* are most favored by Taihangshan macaques. Both are deciduous broadleaf mixed forests, at altitudes of 500–1300 m and 800–1400 m, respectively. Other habitats, such as *Platycladus orientalis* + *Ziziyphus jujuba* + *Vitex negundo* and *Gleditsia heterophylla* + *Cotinus coggyaria* + *Vitex negundo*, are less favored because of their poor shelter and proximity to human activities, but the macaques forage in the poorer-quality habitats during the crop harvesting and tree fruiting periods.

Food Resources

The survey lasted 5 mo, covering the winter season. During the long winter with its poor food supply, Taihangshan macaques foraged and fed mainly on fruits, seeds, and bark of some plants (Table 3). Given the low food availability from November to March, they foraged heavily on bark in the late winter, and fed on the eggs of some insects.

Discussion

The current population of Taihangshan macaques amounts to *ca.* 1400 individuals. Comparing our results with the data of Song and Qu (1996), it appears that the population has increased by *ca.* 400 individuals. In addition, according to data from previous research, there are several macaque groups in areas of the National Nature Reserve that we did not survey (Table 4), so the total population is estimated to be *ca.* 2100. The increase in population suggests that the establishment of the Taihangshan National Nature Reserve has benefited the conservation of an endangered macaque population.

The Taihangshan Mountains area is in an area of continental monsoon climate, with deciduous broadleaf forest being the prevalent vegetation type. In the period from late autumn to early spring, food resources are extremely scarce, with almost all the leaves withered. To survive this long period of food shortage, the macaques are forced to feed on bark, twigs, and roots of crops and withered grass (Table 3); even insect eggs are eaten. Hence, survival conditions are extremely tough during winter and early spring; in winter, the local government annually assigns people to provide additional food for wild macaques. *Quercus variabilis* + *Q. aliena* + *Q. dentata* and *Carpinus turczaninowii* + *C. baronii* + *Carpinus cordata* are preferred habitats because they provide macaques with not only rich foods, but also good shelter.

Unfortunately, there are some problems for the macaques in Taihangshan Mountains area, especially the gradual fragmentation of habitats (Fig. 1). The Jin-Jiao highway, which runs from Jincheng in Shanxi to Jiaozuo in Henan, has been completed and is in use, and another highway, from Jiyuan to Jincheng, is being built. Macaques within the National Nature Reserve have been separated into *ca.* 25 groups by a network of railways, highways, provincial ways, local ways, and minor roads (Fig. 1). With the development of the local economy, fragmentation of habitats may increase, which will inevitably produce genetic isolation (Hu and Zhang 1997; Zhang and Shi 1993) and perhaps threaten the continued existence of the macaque population. Further studies to document population ecology and behavioral ecology are urgently needed.

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References

Brandon-Jones, D., Eudey, A. A., Geissmann, T., Groves, C. P., Melnick, D. J., Morales, J. C., *et al.* (2004). Asian primate classification. *International Journal of Primatology, 25,* 97–164.

Fooden, J. (2000). Systematic review of the rhesus macaque, *Macac mulatta* (Zimmermann, 1780). *Fieldiana Zoology (New Series), 96,* 1–180.

Hu, Z. A., & Zhang, Y. P. (1997). *Genetic diversity of animals and plants in China*. Hangzhou: Zhejiang Science and Technology Press, pp. 66–87.

Jiang, X. L., Wang, Y. X., & Ma, S. L. (1991). Taxonomic and distribution of subspecies of rhesus monkey (*Macaca mulatta*) in China. *Zoological Research, 12,* 241–246.

Liu, R., Xing, M. L., Liu, D. W., & Guo, G. W. (2004). Survey on distribution and population of rhesus macaque in National Nature Reserve of Lishan, Shanxi, China. *Shaanxi Forest Science and Technology, 4,* 26–27.

Lu, J. Q., Lü, J. Q., Zhang, J. J., & Qu, W. Y. (1997). Present status of Taihangshan macaque in Xiuwu of Henan Province. *Chinese Wildlife, 20,* 10–11.

Lü, J. Q., Lu, J. Q., Li, J. Y., & Qu, W. Y. (2002). Feeding habits of *Macaca mulatta* in Taihang Mountains. *Chinese Journal of Ecology, 21,* 29–31.

Qu, W. Y., Li, Y. J., Li, X. H., Hou, J. T., & Wang, F. Z. (1989a). Preliminary investigation of the Rhesus monkeys (*Macaca mulatta*) at Jiyuan and Taihang Mountains in Henan Province. *Journal of Henan Normal University (Natural Science), 2,* 98–101.

Qu, W. Y., Li, Y. J., Xia, X. Y., Lu, Q. Y., & Li, D. S. (1989b). A tentative discussion on the geographical distribution of the primates at Taihang Mountains and in the north area of China. *Journal of Henan Normal University (Natural Science), 2,* 95–97.

Qu, W. Y., Zhang, R. Z., David, M., & Southwick, C. H. (1993). Rhesus monkeys (*Macaca mulatta*) in the Taihang Mountains, Jiyuan county, Henan, China. *International Journal of Primatology, 14,* 607–621.

Song, C. S., & Qu, W. Y. (1996). *Scientific survey of Taihangshan Macaque nature reserve.* Beijing: China Forestry Publishing House, pp. 56–105.

Zhang, R. Z., Chen, L. W., Qu, W. Y., & Chris, C. (2002). *The primates of china: Biogeography and conservation status*. Beijing: China Forestry Publishing House, pp. 104–105.

Zhang, R. Z., Quan, G. Q., Lin Y. L., & Southwick C. H. (1989). Extinction of rhesus monkeys (*Macaca mulatta*) in Xinglong, North China. *International Journal of Primatology, 10,* 375–381.

Zhang, R. Z., Quan, G. Q., Zhao, T. G., & Southwick, C. H. (1991). Distribution of Macaques (*Macaca*) in China. *Acta Theriologica Sinica, 11,* 171–185.

Zhang, Y. P., & Shi, L. M. (1993). Phylogeny of rhesus monkeys (*Macaca mulatta*) as revealed by mitochondrial DNA restriction enzyme analysis. *International Journal of Primatology, 14,* 587–605.