

# Inter-population variation of diets of golden snub-nosed monkeys (*Rhinopithecus roxellana*) in China

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**Abstract:** There have been no studies of food habits of golden snub-nosed monkeys (*Rhinopithecus roxellana*) for over a decade, and descriptions of these diets are primarily qualitative. Comparing diets of golden snub-nosed monkey populations in different regions is important to understand foraging adaptation to different environments. We compared diets of three geographically distinct populations of golden snub-nosed monkey in Shaanxi, Sichuan, Gansu, and Hubei provinces. In total, 136 plant species belonging to 35 families were confirmed as foods of golden snub-nosed monkey. Although nearly half the plant families were shared among all populations, we found significant differences in the three diets. Dietary variation was influenced not only by plant diversity in those different habitats, but also by the feeding trees preferred by monkeys. Monkeys in Shaanxi and Hubei had a similar dietary spectrum, which differed from the populations in Sichuan-Gansu. However, monkeys in Hubei and Sichuan-Gansu showed a similar pattern on food preference whereas populations in Shaanxi exhibited a different food preference. Our analyses suggest that golden snub-nosed monkeys are generalist feeders rather than folivore.

**Key words:** Diet; Food preference; Geographical population; golden snub-nosed monkeys (*Rhinopithecus roxellana*)

## 川金丝猴食谱的地域性差异比较

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**摘要:** 对不同地区川金丝猴食物组成的比较有助于了解其对不同生境食物供应的适应性。本研究通过对陕西川金丝猴猴群食谱的长期记录, 并汇集了国内对四川—甘肃和湖北的川金丝猴食性研究结果, 集成了这三个地理种群川金丝猴各自的地域性食谱, 共计有 136 种植物 (隶属 35 科) 被该物种作为采食对象。对来自这三个不同区域 (陕西、四川—甘肃、湖北) 的川金丝猴食谱组成的比较, 发现有近半数的植物是三个地理种群共同的采食对象, 但其食谱组成差异明显。这可能源于各地植物本身的多样性差异, 及不同地理种群对各种食物采食偏好的不同所致。对其相关聚类分析结果显示, 陕西和湖北的猴群在食谱组成上相近, 但四川—甘肃的猴群与前两个地区猴群的食谱组成差异极大。然而湖北和四川—甘肃种群在食物的选择上采用了近乎相同的偏好倾向, 而陕西的猴群与它们明显不同。我们初步分析认为造成食谱组成和采食偏好差异的原因可能是各地理种群活动地海拔带重叠度不同、森林类型不同、它们在不同林型中活动的时间分配不一。很明显, 就我们目前所掌握的有关川金丝猴食谱组成来看, 该物种不应该仅仅被认为是一个叶食性灵长类动物, 而应该是一个泛化采食者。

**关键词:** 食谱; 地理种群; 食物偏好; 川金丝猴

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### 1 Introduction

Golden snub-nosed monkey (*Rhinopithecus roxellana*), one of the colobines (Bennett and Davies, 1994), only inhabit in remote montane areas (102°-111°E, 30°-35°N) in Sichuan, Gansu, Shaanxi and Hubei provinces in China (Li *et al.*, 2003). Their sacculated stomach was considered an adaptation for feeding heavily on foliage of trees (Peng *et al.*, 1983). Golden snub-nosed monkeys in the Qinling

Mountains of Shaanxi Province are the northern-most population and those in Hubei are the eastern-most. The main body of the populations (about 70% out of total 16 000 individuals, Li *et al.*, 2003) inhabits the Qionglai, Daxiangling, Xiaoxiangling and Minshan Mountains in Sichuan and Gansu. The three extant geographical populations of golden snub-nosed monkey display a discontinuous distribution (Li *et al.*, 2003). There has not been documented individual exchange between these geographically isolated populations for more than 100 years. Although a recent phylogenetic

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study revealed that the three distinct populations of golden snub-nosed monkey did not merit subspecies status (Li *et al.*, 2001), three subspecies have been recognized based on morphological criteria: *R. r. qinlingensis* in Shaanxi has more brilliant golden red pelage and a relatively narrower braincase than *R. r. roxellana* in Sichuan and Gansu. *R. r. hubeiensis* in Hubei has extremely reduced nasal bones, fused premaxillae and paler pelage (Wang *et al.*, 1998; Li *et al.*, 2003).

Since the golden snub-nosed monkey was “re-discovered” in the wild in 1959, dietary composition of this species in its natural habitat had been the focus of many studies (Liu, 1959; Hu *et al.*, 1980; Shi *et al.*, 1982; Li and Shi, 1989; Su *et al.*, 1998; Li, 2001). Studies have not yet reported proportional representation of food item in the diet of any natural groups, but plant species and preference rank of each food plant has been reported in the literature (e.g. Hu *et al.*, 1980; Su *et al.*, 1998; Li, 2001). Dietary comparison among the three geographical populations of golden snub-nosed monkey can help us understand how they are adapted to different habitats and food availability. We made use of published lists of plant species consumed to investigate inter-population dietary variations in food item diversity and preference among these three populations.

Our objectives were to 1) examine to what extent the diet of golden snub-nosed monkey from the populations of Shaanxi, Hubei, Sichuan-Gansu differed; 2) compare dietary preferences among the different populations; and 3) discuss causes of dietary variation among the three monkey populations.

## 2 Methods

Field studies were conducted at Yuhuangmiao, Zhouzhi National Nature Reserve in the Qinling Mountains (Ren *et al.*, 2001), Shaanxi Province. The study group of golden monkeys was followed from May 1997 to February 1999. The group ranged along the slope of the West Ridge in the Yuhuangmiao region at elevations of 1 700 m to 2 000 m. We located sleeping sites of the group during evenings, and began observing the group when the group was successfully located again the next morning.

Field workers remained at a distance ca. 50 – 70 m from the study group. We located trees used for feeding by monkeys using binoculars (8 × 10) and later were identified after the group left. Plant species consumed by monkeys were determined by finding tooth marks on buds, leaves and branches after the group had moved away. We could not always identify food items left on the ground by monkeys. We defined as part of the monkey diet any plant item that was found > 3 times on the ground as a result of monkey activi-

ty. We also included in the diet any plant that we observed to be ingested by monkeys, even if it was recorded less than three times in total. Plant species, plant parts consumed, elevation of the feeding site, date, and time were recorded. If we were unable to identify the plant *in situ*, some branches and other parts such as flowers and fruits of that tree were sampled and taken back to be identified by a botanist.

Feeding trees of the other two geographical populations were extracted from the literature (Hubei: Su *et al.*, 1998; Li, 2001; Sichuan-Gansu: Hu *et al.*, 1980; Zhen and Feng, 1960; Li and Shi, 1989). To eliminate the possibility that plant species did not occur at the respective localities and were thus unlikely to be part of the monkeys' diet, several local floras (e.g. Sichuan Flora, 1981; Hubei Flora: Fu, 2001, 2002) were consulted. If an assumed food plant species was not included in the local botanic books, it was deleted from the diet list. Nomenclature in this study followed Hubei Flora (Fu, 2001, 2002). Because the monkey populations from Sichuan and Gansu Provinces occupy the same geographical range but only different administrative divisions belong to Sichuan and Gansu Provinces respectively and are the same subspecies (Wang *et al.*, 1998) or the same geographical population (Li *et al.*, 2001), we combined diets of animals from Gansu and Sichuan together. We restricted our analysis of dietary components to the species level (trees) and did not attempt to identify the part of the plant that monkeys fed on. We therefore had three geographical populations of golden snub-nosed monkey: Shaanxi, Hubei, and Sichuan-Gansu.

We gave each tree a preference rank (Table 1). Preference ranks of each food tree were further classified into three categories as “common (I)”, “preferred (II)”, and “rare (III)”. To facilitate comparison with existing literature, we considered that food trees classified by previous researchers as “very preferred” corresponded to our “preferred”. Similarly, category “preferred” in previous studies corresponded to our “common”, and “occasional” in previous studies corresponded to our category of “rare”.

The correlation rate was employed to compare the depth of dietary separation of from one geographical population of golden snub-nosed monkey to the pooled diet of this monkey. The rate was calculated as the ratio between number of families/tree species only fed in one geographical populations and number of all families/tree species fed by the three populations of golden snub-nosed monkey. We defined an index of dietary overlap among regions R as  $N_i / (N_1 + N_2 + N_3)$ , where  $N_i$  represents number of shared feeding trees by two or three regional populations.  $N_1$  represents number of trees eaten by *R. r. qinlingensis*,  $N_2$  by

*R. r. roxellana* and N3 by *R. r. hubeiensis*.

Chi-square method was used to examine the differences in number of the plant diets among the three populations. Since many plants were shared by the three geographical populations of golden snub-nosed monkeys, we used cluster analysis method to investigate correlations among the diets. Analyses were done using SPSS 12.0.

### 3 Results

#### 3.1 Diet of the three geographical populations of golden snub-nosed monkey

In total, golden snub-nosed monkey has been documented to feed on 136 plant species belonging to 35 families (Table 1). The number of tree species used in diets differed among populations (Chi-square test:  $\chi^2 = 10.63, P = 0.005$ , two-tailed).

**Table 1 Wood and liana foods of *R. roxellana* in three geographical populations in four different provinces**

Plant species ( Family)	Geographical groups						Source <sup>1</sup>
	Shaanxi		Sichuan & Gansu		Hubei		
	Food <sup>2</sup>	Preferred rank <sup>3</sup>	Food <sup>2</sup>	Preferred rank <sup>3</sup>	Food <sup>2</sup>	Preferred rank <sup>3</sup>	
<i>Pinus tabulaeformis</i> ( Pinacea)	1	I	1	I	0		4
<i>P. armandii</i> ( Pinacea)	1	I	1	I	1	I	1, 2, 4, 7
<i>P. massoniana</i> ( Pinacea)	0		1	I	0		4
<i>Abies fargesii</i> ( Pinacea)	0				1	I	1, 2, 7
<i>A. faxomiana</i> ( Pinacea)	0		1	I	0		4
<i>Populus davidiana</i> ( Salicaceae)	1	I		I	1	I	2, 4, 7
<i>P. wilsonii</i> ( Salicaceae)	0		0		1	II	2, 7
<i>P. purdomii</i> ( Salicaceae)	1	I	0		0		
<i>P. hopeiensis</i> ( Salicaceae)	0		1	I	0		3
<i>P. lasiocarpa</i> ( Salicaceae)	0		1	II	1	I	2, 3
<i>Salix sinica</i> ( Salicaceae)	1	II	0		0		-
<i>S. hypoleuca</i> ( Salicaceae)	0		0		1	III	2
<i>S. wallichiana</i> ( Salicaceae)	0		0		1	I	2
<i>S. hylonima</i> ( Salicaceae)	1	II	0		0		-
<i>S. sinopurpurea</i> ( Salicaceae)	1	II	0		0		-
<i>Pterocarya hupeiensis</i> ( Juglandaceae)	1	I	0		0		-
<i>P. macroptera</i> ( Juglandaceae)	1	I	0		0		
<i>Juglans cathayensis</i> ( Juglandaceae)	0		1	II	0		3
<i>Betula utilis</i> ( Betulaceae)	1	I	1	II	1	II	1, 2, 5, 7
<i>B. utilis var. sinensis</i> ( Betulaceae)	1	I	1	II	1	II	1, 2, 4, 5, 6, 7
<i>B. luminifera</i> ( Betulaceae)	1	I	1	I	1	I	1, 2, 4, 7
<i>Corylus heterophylla</i> ( Betulaceae)	1	I	0		0		-
<i>C. chinensis</i> ( Betulaceae)	1	I	0		0		-
<i>C. ferox var. thibetica</i> ( Betulaceae)	1	I	0		1	I	2
<i>C. polyneura</i> ( Betulaceae)	1	II	1	II	1		2, 3, 6
<i>C. chinensis</i> ( Betulaceae)	0		0		1		1
<i>Quercus liaotungensis</i> ( Fagaceae)	1	II	0		0		-
<i>Q. variabilis</i> ( Fagaceae)	1	II	1	I	0		4
<i>Q. glandulifera var. brevipetiolata</i> ( Fagaceae)	0		0		1	I	2
<i>Q. cocciferoides</i> ( Fagaceae)	0		1	II	1		2, 5
<i>Q. aliena var. acuteserrata</i> ( Fagaceae)	1		1	I	1	III	2, 4
<i>Q. baronii</i> ( Fagaceae)	1	III	0		0		-
<i>Castanea sequinii</i> ( Fagaceae)	1	II	0		0		-
<i>C. mollissima</i> ( Fagaceae)	1	II	0		1	III	2
<i>Fagus engleriana</i> ( Fagaceae)	0		0		1	I	2, 7
<i>Ulmus bergmanniana</i> ( Ulmaceae)	1	II					-
<i>U. macrocarpa</i> ( Ulmaceae)	1	II					-
<i>Morus australis</i> ( Moraceae)			1	II			4
<i>M. Mongolica</i> ( Moraceae)			1	I			6
<i>Ficus heteromorpha</i> ( Moraceae)	1	II	1	I			3
<i>Broussonetia papyrifera</i> ( Moraceae)	1	III	0		1	II	7
<i>Coriaria nepalensis</i> ( Coriariaceae)	0		0		1	II	2
<i>Euptelea pleiosperma</i> ( Eupteleaceae)	1	III	0		1	III	7
<i>Magnolia bioudii</i> ( Magnoliaceae)	1	II	0		0		-
<i>Schisandra sphenanthera</i> ( Schisandraceae)	1	II	1	I	0		6
<i>S. glaucescens</i> ( Schisandraceae)	0		0		1	III	2
<i>S. rubriflora</i> ( Schisandraceae)	0		1	I	0		5
<i>Tetracentron sinense</i> ( Tetracentraceae)	1	II	0		0		-
<i>Lindera obtusiloba</i> ( Lauraceae)	1	II	0		1	I	2, 7

Continued from table 1

Plant species ( Family)	Geographical groups						Source <sup>1</sup>
	Shaanxi		Sichuan & Gansu		Hubei		
	Food <sup>2</sup>	Preferred rank <sup>3</sup>	Food <sup>2</sup>	Preferred rank <sup>3</sup>	Food <sup>2</sup>	Preferred rank <sup>3</sup>	
<i>L. glauca</i> ( Lauraceae)	1	III	1	I	1	III	6, 7
<i>Litsea tsinlingensis</i> ( Lauraceae)	1	II	0		0		-
<i>L. szechuanica</i> ( Lauraceae)	0		1	II	0		3
<i>L. rubescens</i> ( Lauraceae)	1	II	0		0		-
<i>L. pungens</i> ( Lauraceae)	0		1	I	1	III	2, 5, 7
<i>L. ichangensis</i> ( Lauraceae)	0		0		1	I	2
<i>L. mollifolia</i> ( Lauraceae)	0		0		1	III	7
<i>Hydrangea xanthoneura</i> ( Saxifragaceae)	1	III	0		0		-
<i>Sinowilsonia henryi</i> ( Hamamelidaceae)	1	II			1	II	1
<i>Malus baccata</i> ( Rosaceae)	1	I	0		0		-
<i>M. sieboldii</i> ( Rosaceae)	1	I					-
<i>M. rufopilosa</i> ( Rosaceae)	0		1	II	0		5
<i>M. halliana</i> ( Rosaceae)	0		0		1	I	2
<i>M. kansuensis</i> ( Rosaceae)	1	I	0		0		-
<i>Sorbus koehneana</i> ( Rosaceae)	1	I	0		0		-
<i>S. hupehensis</i> ( Rosaceae)	1	I	0		1	I	2, 7
<i>S. yunnanensis</i> ( Rosaceae)	0		1	I	0		3, 5
<i>S. xanthoneura</i> ( Rosaceae)	0		1	I	0		5
<i>Prunus pseudocerrata</i>	1	II	0		0		-
<i>P. tomentosa</i> ( Rosaceae)	0		1	I	0		6
<i>P. padus</i> ( Rosaceae)	0		1	II			5
<i>P. clarifolia</i> ( Rosaceae)	0		1	I	0		5
<i>P. discadenia</i> ( Rosaceae)	0		0		1	I	2
<i>P. salicina</i> ( Rosaceae)	0		0		1	III	2
<i>Maddenia insisoserrata</i> ( Rosaceae)	1	II	0		0		-
<i>M. hypolenuca</i> ( Rosaceae)	0		1	II	0		5
<i>Crataegus hupehensis</i> ( Rosaceae)	0		0		1	I	2
<i>Euonymus alatus</i> ( Celastraceae)	1	II	0		1	I	2
<i>E. porphyreus</i> ( Celastraceae)	0		1	I	0		5
<i>E. phellomana</i> ( Celastraceae)	1	II	0		0		-
<i>E. myriantha</i> ( Celastraceae)	1	II	0		0		-
<i>Celastrus geminatus</i> ( Celastraceae)	1	II	1	II	0		3
<i>Staphylea bumalda</i> ( Staphyleaceae)	1	III	0		0		-
<i>S. halocapa</i> ( Staphyleaceae)	1	III	0		0		-
<i>Tapiscia sinensis</i> ( Staphyleaceae)	1	II	0		0		-
<i>Acer davidii</i> ( Aceraceae)	1	I	0		1	II	2
<i>A. oliverianus</i> ( Aceraceae)	1	I	0		0		-
<i>A. mono</i> ( Aceraceae)	1	I	0		1	II	2
<i>A. maximowiczii</i> ( Aceraceae)	0		1	I	1	II	2, 3, 4
<i>A. erianthum</i> ( Aceraceae)	0		0		1	I	2
<i>A. leiopodum</i> ( Aceraceae)	0		1	II	0		5
<i>A. caudatum</i> ( Aceraceae)	0		1	II	0		5
<i>A. tetramerum</i> ( Aceraceae)	1	I	0		0		-
<i>A. francheti</i> ( Aceraceae)	1	I	1	II	0		5
<i>Aesculus chinensis</i> ( Hippocastanaceae)	1	III	0		1	III	2
<i>Sabia japonica</i> ( Sabiaceae)	1	III	0		0		-
<i>Meliosma veitchiorum</i> ( Sabiaceae)	0		0		1	II	2
<i>Hovenia dulcis</i> ( Rhamnaceae)	1	II	1	I	0		6
<i>H. acerba</i> ( Rhamnaceae)	1	II	0		0		-
<i>Tilia pouciostata</i> ( Tiliaceae)	1	II	1	I	0		3
<i>T. oliveri</i> ( Tiliaceae)	0		0		1	III	2
<i>Actinidia chinensis</i> ( Actinidiaceae)	1	I	0		1	II	1
<i>A. kolomikta</i> ( Actinidiaceae)	1	I	0		1	II	1
<i>A. callosi</i> ( Actinidiaceae)	1	I	0		1	II	1
<i>A. venosa</i> ( Actinidiaceae)	0		1	I	0		5
<i>A. tetramera</i> ( Actinidiaceae)	1	I	0		1	II	1
<i>Clematoclethra tiliacea</i> ( Actinidiaceae)	0		1	II	0		5
<i>Elaeagnus bockii</i> ( Elaeagnaceae)	1	III	0		0		-
<i>E. umbellata</i> ( Elaeagnaceae)	1	III	0		0		-
<i>Alangium chinensis</i> ( Alangiaceae)	1	II	0		0		-

Continued from table 1

Plant species ( Family)	Geographical groups						Source <sup>1</sup>
	Shaanxi		Sichuan & Gansu		Hubei		
	Food <sup>2</sup>	Preferred rank <sup>3</sup>	Food <sup>2</sup>	Preferred rank <sup>3</sup>	Food <sup>2</sup>	Preferred rank <sup>3</sup>	
<i>Acanthopanax giraldii</i> ( Araliaceae)	0		1	II	0		3, 5
<i>Aralia chinensis</i> ( Araliaceae)	1	II	1	II	1	II	1, 3, 5, 7
<i>Tetrapanax papyriferus</i> ( Araliaceae)	0		0		1	III	7
<i>Kalopanax septemlobus</i> ( Araliaceae)	0		0		1	III	2
<i>Cornus macrophylla</i> ( Cornaceae)	1	III	0		1	I	2
<i>Dendrobenthamia anyustata</i> ( Cornaceae)	1	III	0		0		
<i>Bothrocaryum controversum</i> ( Cornaceae)	1	III	0		1	II	2, 7
<i>Helwingia chinensis</i> ( Cornaceae)	1	II	0		0		-
<i>H. japonica</i> ( Cornaceae)	1	II	1	II	1	II	5, 7
<i>Decaisnea fargesii</i> ( Lardizabalaceae)	1	III	1	III	1	III	2, 3
<i>Fraxinus retusa</i> ( Oleaceae)	1	II	0		0		-
<i>F. mandshurica</i> ( Oleaceae)	1	II	0		0		-
<i>F. platypoda</i> ( Oleaceae)	1	II	0		0		-
<i>F. paxiana</i> ( Oleaceae)	1	III	0		0		-
<i>Syringa villosa</i> ( Oleaceae)	1	II	1	II	0		5
<i>Lonicera saccata</i> ( Caprifoliaceae)	0		1	II	0		3
<i>L. chrysantha</i> ( Caprifoliaceae)	0		1	I	0		6
<i>L. fangutica</i> ( Caprifoliaceae)	0		1	I	0		6
<i>Sambucus williamsii</i> ( Caprifoliaceae)	1	II	0		0		-
<i>Viburnum betulifolium</i> ( Caprifoliaceae)	1	I	0		0	III	2
<i>V. dilatatum</i> ( Caprifoliaceae)	1	II	0		0	III	2
<i>Ampelopsis</i> sp. ( Vitaceae)	1	II	0		1	III	1, 7
<i>Albizia julibrissin</i> ( Mimosaceae)	1	III	0		1	II	2
<i>Rhododendron oreodoxa</i> ( Ericaceae)	0		1	II	0		5
<i>R. clementinae</i> ( Ericaceae)	0		1	II	0		5, 6
<i>R. pachytrichum</i> ( Ericaceae)	0		1	II	0		5
<i>R. calophytum</i> ( Ericaceae)	0		1	I	0		5
<i>R. fargesii</i> ( Ericaceae)	0		0		1	III	7
<i>Zanthoxylum bungeanum</i> ( Rutaceae)	1	III	0		1	III	2
<i>Catalpa longicarpa</i> ( Bignoniaceae)	0		0		1	III	2
<i>Toxicodendron veriniciiflum</i> ( Anacardiaceae)	1	II	0		1	I	2
<i>Rhus chinensis</i> ( Anacardiaceae)	0		0		1	II	2, 7
<i>Securinega suffruticosa</i> ( Euphorbiaceae)	0		0		1	I	2

1) 1: Zhu Z Q & Song C S, 1999; 2: Li Y M, 2001; 3: Li G H & Shi D C, 1989; 4: Shi D C *et al.*, 1982; 5: Hu J C *et al.*, 1980; 6: Zhen R L & Feng Y X, 1960; 7: Su *et al.*, 1998.

2) 1 = Plant that has been identified as a food for this population; 0 = plant that has not been identified as a food for this population.

3) Feeding preference rank: I common; II preferred; III rare.

### 3.2 Diet comparisons at the family level of plants among the three geographical populations

Plants from 15 families were shared among diets of monkeys from all 3 regions: Pinaceae, Salicaceae, Betulaceae, Fagaceae, Moraceae, Schisandraceae, Lauraceae, Rosaceae, Aceraceae, Tiliaceae, Actinidiaceae, Araliaceae, Cornaceae, Lardizabalaceae, Caprifoliaceae. Ericaceae was the only family shared in diets of monkeys in both Sichuan-Gansu and Hubei. The proportional differences between the two areas in the number of plant families at family level in Sichuan-Gansu region was 11.4% (4/35). Three families (Oleaceae, Celastraceae and Rhamnaceae) were used by monkeys in Sichuan-Gansu and Shaanxi. Dietary overlap between the two areas was about 8.6% (3/35). Eight families (Juglandaceae, Hamamelidaceae, Hippocastanaceae, Sabiaceae, Vitaceae, Mimosaceae,

Rutaceae, and Anacardiaceae) were food sources in Shaanxi and Hubei. The dietary overlap was 22.8% (8/35).

Six families were used only in the Qinling Mountains in Shaanxi Province: Ulmaceae, Tetracentraceae, Saxifragaceae, Staphyleaceae, Elaeagnaceae, and Alangiaceae. The deviation rate of the diet at family level was about 48.6% (17/35) in Shaanxi. Three families were in Hubei only: Coriariaceae, Bignoniaceae, and Euphorbiaceae. The deviation rate of diet at family level was ca. 34.2% (12/35).

### 3.3 Diet comparisons at the species level of plant among the three geographical populations

Forty-three food plants belonging to 6 families were recorded only in Shaanxi; 29 plants were used exclusively in Sichuan-Gansu; 23 only in Hubei (Table 1). The number of regional plant species in diets dif-

ferred among geographical regions ( Chi-square test:  $\chi^2 = 6.653$  ,  $df = 2$  ,  $P = 0.036$  , two-tailed) .

Twenty plant species were occurred in diets in both Shaanxi and Hubei. Dietary overlap between Shaanxi and Hubei was 21.3% ( 29/136) . Ten species occurred in diets in both Shaanxi and Sichuan-Gansu , where dietary overlap was 13.9% ( 19/136) . Three species were used in both Hubei and Sichuan-Gansu: *Populus lasiocarpa* , *Litsea pungens* and *Acer maximowiczii*. Dietary overlap was 8.8% ( 12/136) .

Nine plants were preferred differently to feed on among the three populations of golden snub-nosed monkeys: *Pinus armandii* , *Populus davidiana* , *Betula utilis* , *Betula utilis* var. *sinensis* , *Betula luminifera* , *Lindera glauca* , *Aralia chinensis* , *Helwingia japonica* and *Decaisnea fargesii*.

### 3.4 Relatedness of the diet for the three geographical populations of golden snub-nosed monkey

Results of a hierarchical cluster analysis on the diet composition and food preference are illustrated in Fig. 1 and Fig. 2. The dendrogram in Fig. 2 was based on preference levels for each plant species ( Table 1) . The dendrogram in Fig. 1 indicated that the two groups in Shaanxi and Hubei showed a very similar diet spectrum. Sichuan-Gansu group , however , displayed a remarkable separation from them. Monkeys in Sichuan-Gansu and Hubei fed similarly to each other , but differently from those in Shaanxi.

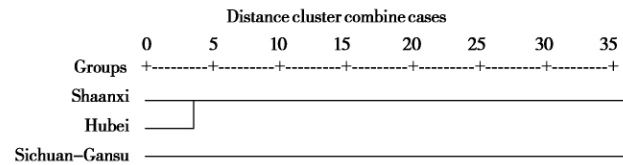


Fig. 1 Hierarchical cluster of the three geographical groups of the golden snub-nosed monkey based on dietary components ( Foods: Potential foods)

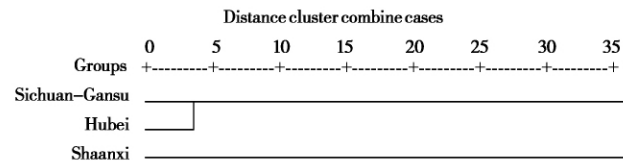


Fig. 2 Hierarchical cluster of the three geographical groups of *R. roxellana* on the food preference in rank

## 4 Discussion

### 4.1 Diet of the three geographical populations of golden snub-nosed monkeys

One hundred and thirty-six plant species belonging to 35 families were confirmed as food resources of golden snub-nosed monkey. That so many plant species were eaten by golden snub-nosed monkeys suggests that the monkey might not be a folivorous specialist ( Hu

*et al.* , 1980; Su *et al.* , 1998; Li , 2001) . Dietary variations in golden snub-nosed monkey were primarily due to different distributions of vegetation. For example , *Sorbus yunnanensis* and *Rhododendron pachytrichum* are only distributed in Sichuan , *Catalpa longicarpa* is found only in Hubei , *Fraxinus mandshurica* , *Salix sinopurpurea* , *Salix sinica* and *Populus purdomii* are present only in Shaanxi.

Nearly half number of plant families across the three geographical regions jointly foraged by the monkey suggested that high dietary diversity was resulted from increasing number of tree species with limited plant families. The plant in the same family might provide the same nutritional components the monkey required indispensably since the monkey consumed the same parts of trees in the same family with no exception. Furthermore , it also suggested that diets of golden snub-nosed monkey are still conservative or have been broadened at a very slow speed up to now. That how many and what trees played such a “fallback food” role in feeding behavior of golden snub-nosed monkey need further investigation.

Dietary variations were higher in Shaanxi than in Sichuan-Gansu and Hubei. However , feeding much more plant species did not mean that monkeys in Shaanxi live in better feeding condition but foraged most time in deciduous broadleaf forests ( Li and Liu , 1994) than those in Hubei ( Su *et al.* , 1998) and Sichuan-Gansu ( Hu *et al.* , 1980) .

Golden snub-nosed monkey highly preferred rare plants in its habitat as food but not the most common species might be due to its “nutritional wisdom” ( Rozin , 1969; Wrangham and Waterman , 1981) , i. e. the animal innately knew what nutrients its body needed , and where to obtain them. Study on mantled howler monkeys ( *Alouatta seniculu* , Glander , 1981) supported this hypothesis.

### 4.2 Environmental factors for dietary variations in golden snub-nosed monkeys

Dietary variations are absolutely definite among natural conspecific groups of nonhuman primates. For example , dietary differences showed some group-specific characteristics among the groups with overlapping home ranges in red colobus ( *Procolobus badius* ) at Kibale National Park ( Chapman *et al.* , 2002) . Diet of golden snub-nosed monkey was different in the dietary component at tree species level. What environmental factors contributed powerfully to such a dietary variation is hard to investigate empirically. So the following part tried to explain the dietary difference by elevations , climate , vegetation type and ranging patterns of different population of golden snub-nosed monkeys.

Generally , elevations and climate determined the vegetation types in a given area and the latter combining its terrains formed a primate ’ s habitat. Then ani-

mals adapt the complex habitat by developing some ranging patterns.

Groups of golden snub-nosed monkey moved about in Shaanxi, Hubei and Sichuan-Gansu at different elevation belts. For example, the altitude range of the monkey group in Shaanxi is between 1 400 – 2 400 m (Li and Liu, 1994) and 1 700 – 2 000 m of our study group 20 in the present study; the altitude ranges from 2 000 m to 2 600 m in Hubei (Su *et al.*, 1998; Ren *et al.*, 2000) and between 2 200 – 3 300 m in Sichuan (Hu *et al.*, 1980). There was no overlap on the elevation in Shaanxi and Hubei when 2 000 m was taken into account; neither was between Shaanxi and Sichuan. Overlap of altitude between Sichuan and Hubei was ca. 30.8%. Clearly, the up-limit of altitude in Shaanxi is the base line of that in Hubei. Only the monkeys in Sichuan and Hubei overlapped partly. The overlapped elevation belt did not favor a similar dietary contest between populations of golden snub-nosed monkey in Hubei and Sichuan (Fig. 1). However, the geographical groups of Hubei and Sichuan-Gansu had a similar food preference (Fig. 2). This suggested that elevation overlap might help form similar ranging behavior while foraging in those regional populations.

Food choice including food item availability and forest types in which the group preferred to stay mostly influenced the diet components. Natural groups of golden snub-nosed monkey are under the same climate conditions with similar seasonal variations (Hu *et al.*, 1980; Li and Liu, 1994; Zhang, 1995; Su *et al.*, 1998; Li, 2001). The same climate and seasonality throughout all the habitats of golden snub-nosed monkey suggested that vegetation type in the regions might be similar at the same elevation. We hypothesized that if a monkey inhabits in the same forest at the same elevation, then it will have a same or similar dietary composition. Our findings in golden snub-nosed monkeys showed that they have different dietary components with the same vegetation types: deciduous broadleaf forests, deciduous broadleaf and coniferous mixed forests and coniferous forests (Hu *et al.*, 1980; Li and Liu, 1994; Su *et al.*, 1998). Then vegetation type contributed little to cause the difference of diets among the geographical populations of golden snub-nosed monkeys.

We then turned to ranging patterns like time spent in different forest types in the literature of ecology of golden snub-nosed monkeys. We assumed that time spent the groups stayed in different vegetation types might impact diet variations of different groups of golden snub-nosed monkeys. It was reported that Shaanxi monkey groups spent about 77.5% time in deciduous broadleaf forests, 20.8% time in deciduous broadleaf and coniferous mixed forest and only 1.7% time ranges in coniferous forest annually (Li and Liu, 1994). The groups in Hubei spend ca. 90.4% time in

deciduous broadleaf and coniferous mixed forests, only 5.9% time in deciduous broadleaf forests and 3.7% time in coniferous forest (Su *et al.*, 1998). Groups in Sichuan stay about 11.8% time in the coniferous forest, 37.2% time range in deciduous forest and 51% time in deciduous and coniferous mixed forest (Hu *et al.*, 1980). That more than 95% time stayed in deciduous broadleaf forests and deciduous broadleaf and coniferous mixed forests in Hubei and Shaanxi supported that golden snub-nosed monkey groups in these two areas developed a similar dietary component (Fig. 1).

A nutritional analysis of the mix of food preferred by the different populations could be a further domain in trying to explain different dietary preferences for golden snub-nosed monkey. Food items categorized into leaves, fruits, seeds, barks, twigs etc might be another way to investigate feeding strategy of this monkey.

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