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Altitudinal ranging of the Guizhou golden monkey (*Rhinopithecus brelichi*): Patterns of habitat selection and habitat use

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ABSTRACT

Between September 2011 and August 2013, we studied patterns of habitat selection and habitat use in the Guizhou golden monkey (*Rhinopithecus brelichi*) at Fanjingshan National Nature Reserve, China. the monkeys ranged across elevations between 1432 and 2100 m. Within this altitudinal range we recorded 125 genera, 72 families, and 236 tree and vine species. From these, the Guizhou golden monkey was observe to consume food items from 104 species, 51 genera, and 31 plant families. Individual food species exploited by the monkeys varied significantly across seasons and by altitude. From October to March (Spring/Winter), the monkeys foraged across their entire 700 m elevation range. From April to September, however, individuals primarily restricted their activities to a narrow zone of between 1,700 m and 1,900 m. Our data indicate that seasonal changes in the Guizhou golden monkey dietary and ranging behavior are attributable to habitat and altitudinal specific differences in the availability of plant foods. The fact that the Guizhou golden monkey actively targets common plant foods appears to represent a low energy foraging strategy designed to minimize search time and travel. Finally, due to their ranging pattern associated with habitat specificity, all of the remaining forested habitat between 1432 and 2100 m should be protected.

1. Introduction

The Guizhou golden monkey (*Rhinopithecus brelichi*) is one of the most endangered (EN) primate species and has first-level protection status for wild animals in China (IUCN, 2017). It is endemic to China. In 1993, the Fanjingshan National Nature Reserve reported that the population size of Guizhou golden monkeys was estimated at 764 individuals (Yang et al., 2002). A recent population survey indicates that the population size is approximately 750 monkeys (Xiang et al., 2009), almost

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unchanged from 1993. However, the range of habitats available to the Guizhou golden monkey has changed dramatically. In the 1960s, Guizhou golden monkeys were often observed at an elevation of 500 m (Quan and Xie, 2002). In the 1980s, they were commonly observed at 800 m and above (Quan and Xie, 2002). Studies conducted in 1990s and between 2000 and 2009 showed an elevational range of from 1400 to 2100 m (Quan and Xie, 2002; Xiang et al., 2009; Niu et al., 2010). Niu et al. (2010) suggested that anthropogencially caused changes in this primate's ranging behavior and reduced access to rsuitable forest habitat, may result in extinction. At present, this species only occupies a narrow habitat in the Fanjingshan National Nature Reserve (FNNR), in areas characterized by steeply sloped mountainous ravines. In addition, an important behavioral characteristic of the snub-nosed monkeys is long-term philopatry (Kirkpatrick et al., 1998; Li et al., 2000, 2010; Ren et al., 2010). It appears that in the absence of newly available habitat, the species population size has remained unchanged for decades. In addition, mitochondrial DNA of the Guizhou golden monkey is characterized by lower diversity than *R. bieti* and *R. roxellana* (Zhou et al., 2016; Yang et al., 2012; Kolleck et al., 2013). Habitat specialization and the limited ability of individuals in nearby bands to migrate across nonsuitable habitat into other bands, may be the primary reason for low genetic diversity.

Similar to other Chinese snub-nosed monkey species, habitat destruction is a potential threat to the survival of the Guizhou golden monkey (Xiao et al., 2003; Xiang et al., 2007a), and suitable habitat at low altitudes has come under increased pressure in the FNNR. A similar situation has been reported in Mt. Fanjing, which maintains a well-known tourist center and a population of 750 of Guizhou golden monkey. Here, a tourist ropeway system was built in the southeast part of the reserve in 2009 and the Fanjing Mountain Road was built in 2011. Due to the development of tourism at both FNNR and Mt. Fanjing, the habitat of the monkey has become severely disturbed, and there is little systematic information on the effects of tourism on changes in habitat utilization in this endangered primate species.

In recent years, several studies have investigated diet, habitat use of the Guizhou golden monkey (Guo et al., 2007; Xiang et al., 2007b; Li, 2006; Zhou et al., 2006; Li et al., 2010). For example, Yang and Emily, 2002 set up 50 quadrats totaling 2.5 ha at an elevation of 1700–2100 m in the reserve, however the monkeys were not observed to enter these quadrants. Wu et al. (2004) performed a comprehensive analysis of the temperature, vegetation, and food types such as evergreen broadleaf forest, evergreen and deciduous broadleaf mixed forest, deciduous broadleaf naturally consumed by the Guizhou golden monkey in the reserve. He determined that regions between an elevational range of 1500 m–1700 m provided the most suitable habitat for this species. Finally, Yang et al. (2013) demonstrated that the primary indicators of the presence of *R. brelichi* are the gradient, slope aspect, elevation, vegetation type and degree of human disturbance. These authors concluded that evergreen and deciduous broad-leaved mixed forest at an elevational range of 1200 m to 1800 m provided the most suitable habitat for the Guizhou golden monkey. In their study, however, critical information including behavioral data, plant species diversity and food resources consumed by the Guizhou golden monkey was not included. Given the limitations of previous studies, we continue to lack the type of detailed information on habitat selection and utilization that is required to promote effective protection measures for this Critically Endangered primate species.

In this study, we conducted field observations of the activity and ranging patterns of Guizhou golden monkey's across an elevational range of from 1432 m to 2100 m in the Fanjingshan National Nature Reserve. We examined evidence for seasonal differences in habitat exploitation by analyzing dietary data and correlating activity with vegetation, elevation, and food species distributions. This is the first detailed study on habitat selection and utilization of the Guizhou golden monkey across different seasons.

2. Methods

2.1. Study site

This study was conducted at the Fanjingshan National Nature Reserve (FNNR), located in the northeast of Guizhou Province. The reserve has a total area of 567 km^2 (27°46′50″–28°1′30″N, 108°45′55″–108°48′30″E). Annual rainfall is 1100–2600 m mm, and annual average temperature is 5.0–17 °C. Temperature is lowest in January, when it ranges from 3.1 to 5.1 °C. Temperature is highest in July, and ranges from 15 to 27 °C. Temperature is known to decrease with altitude, with an annual average temperature reduction of 0.5–0.6 °C/100 m.

2.2. Behavioral data collection

We observed the behavior of monkeys from September 2011 to August 2013 during five consecutive days per month (1st to 5th of each month). On average, 9 h of observational data were collected per day, using a 5 min scan sampling method at 15-min intervals (Altmann, 1974). All observations involved the use of a Kowa TSN-883 telescope, from a distance of 50 m and 100 m. Behavioral categories included: location, feeding, grooming, resting, fighting, and playing. When the monkeys were feeding, we identified the plant part consumed (buds, young leaves, leaves, flowers, bark and fruits). If we were unable to identify the plant taxon in fhe field, we collected leaf samples from the feeding tree or a nearby tree of the same taxon for later identification after the monkeys had left the feeding site. Collection location was recorded using a GPS (Garmin Etrex 20). When GPS data could not be directly obtained, the location of each food remnant was estimated using multiple landmarks on a 1:10,000 topographic map. Phenological data for trees in which the monkeys fed were gathered by recording the presence/absence of buds, mature leaves, young leaves, fruits and flowers in the tree while or soon after the monkeys fed.

Table 1
Sampling quadrat allocations at various elevation ranges.

Elevation (m)	Number of quadrats	Area (m^2)
1500	22	1.1×10^4
1700	30	1.5×10^4
1900	33	1.65×10^4
2100	15	0.75×10^4
Total	100	5×10^4

2.3. Vegetation investigation and botanical plot analysis

To further investigate the relationship between the monkeys behavior and ecology, botanical plots were set up at 1,500, 1,700, 1,900, and 2100 m in the FNNR. This is the altitudinal range the monkeys exploited. Each plot was 50 m (altitude) × 10 m (width) or 500 m^2. Plot size was based on the steeply sloped nature of the landscape of the Fanjingshan Mountain. The total number of botanical plots constructed and monitored was 100 (Total area of the plots equals 5 ha; Table 1). The data recorded from the botanical plots included plant species, the number of woody plants and vines, diameter at the breast height of trees (DBH>10 cm), crown width, base coverage (C) (basal area), and tree height of all woody plants (DBH >10 cm). We classified seasons as follows: Spring (January–March); Summer (April–June); Fall (July–September); Winter (October–December).

2.4. Data analysis

The importance value index (IVI) of woody plants between 1500 and 2100 m as well as for each individual elevation category was calculated using the data recorded for the sampling quadrats. The following equations were used:

Relative base coverage = (Coverage of one plant species/Total coverage of all plants in the plot) × 100
Relative frequency = (Frequency of one plant species/Total frequency of all plants in the plot) × 100
Relative density = (Density of one plant species/Total density of all plants in a plot) × 100
IVI = Relative coverage + Relative frequency + Relative density

Species diversity in vegetation communities at different elevations was analyzed using the following method:

$$\text{Shannon} - \text{Wiener diversity index (H)} = \sum_{i=1}^{s} P_i \log_2 P_i \text{ , evenness index (E)} = \text{H/Hmax.}$$

A Spearman two-tailed test was applied for co-relational analyses. The variables included in this analysis were the frequency of individual components of the Guizhou golden monkey activity pattern, crown breadth, DBH, tree height, base coverage percentage, total number of plants, total number of species, the number of food items, the number of food species, the importance value index of trees, and the importance value index of the feeding trees (Table 2).

3. Results

3.1. Activity range

Based on 24 months of field observation, 99% of the time the Guizhou golden monkeys were observed at an elevations of between 1500 m and 2100 m (Fig. 1)(n = 320). On only 3 occasions (1%) were the monkeys observed at an elevation between 1400 m and 1500 m (Table 3). The lowest recorded elevation was 1432 m, and the highest was 2100 m.

Table 2
Vegetation quadrat sampling results and related calculation values.

Elevation (m)	TN	STN	FRTN	FRSTN	IVIT	IVIFT (%)	TH (m)	CD (m)	DBH (m)	C	F
1500	618	82	333	40	293.63	65.56	7.14	3.78	0.46	13.84	75
1700	1680	132	1017	65	300.22	65.59	8.10	3.85	0.42	27.14	96
1900	1178	94	799	60	299	72.9	8.11	4.13	0.16	32.86	103
2100	546	49	300	32	300	58.7	8.56	3.86	0.16	17.02	50
Total	4022	183	2449	84	298.21	66.37	8.03	3.91	0.3	90.86	324

Note: TN - Tree number; STN - Species number of trees; FRTN - Number of feeding trees; FRSTN - Species number of feeding trees; IVIT - Importance value index of trees; IVIFT - Importance value index of feeding trees; TH - Tree height; CD - Crown breadth; DBH - Diameter at breast height; C - Base coverage; F - Frequency of monkey occurrence.

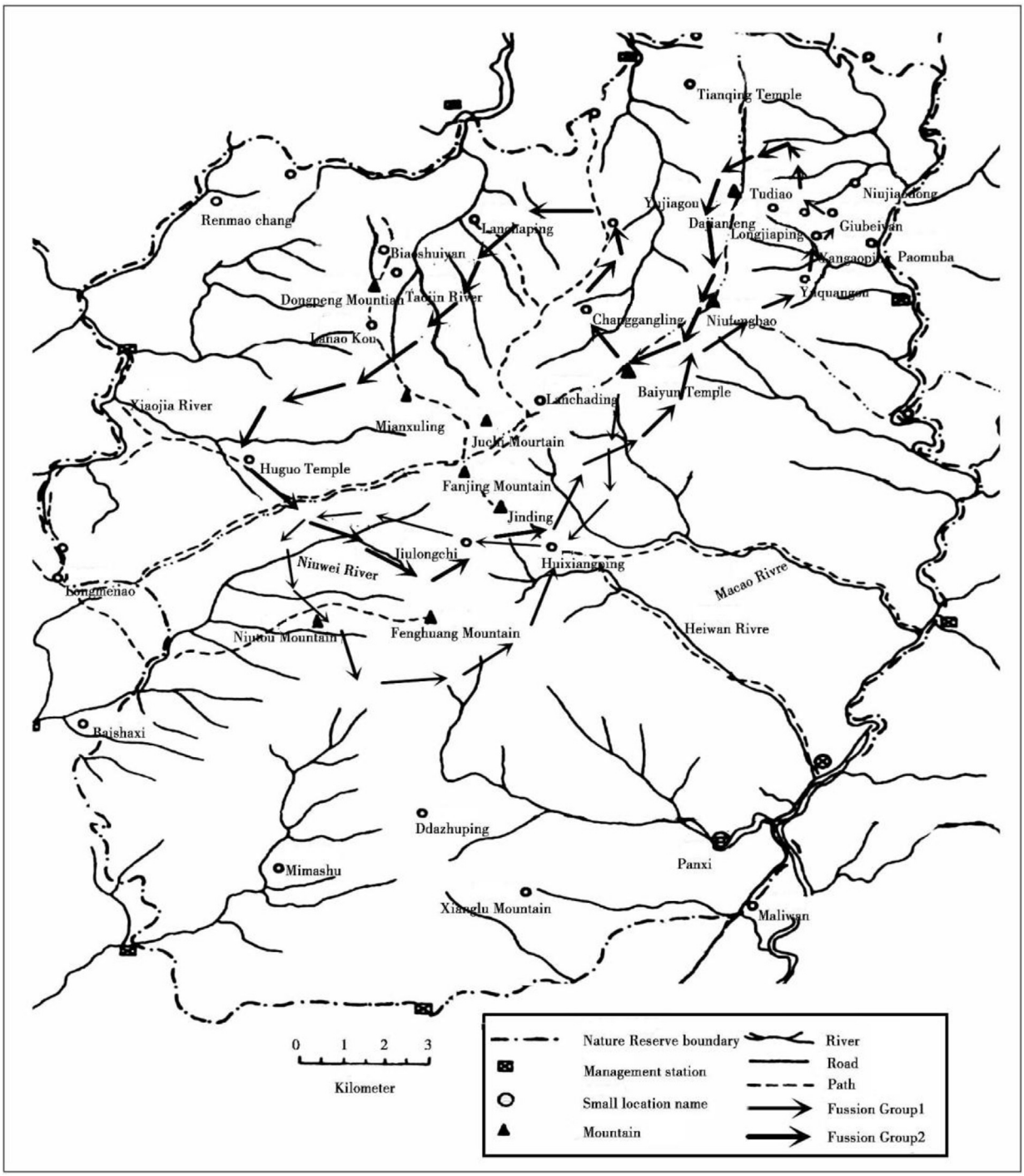

Fig. 1. The activity range of the *Rhinopithecus brelichi* in Fanjingshan National Nature Reserve. (We quote from Guo et al. (2007). The population of *Rhinopithecus brelichi* in Fanjingshan National Nature Reserve, Guizhou, China. Acta Theriologica Sinica, 37 (1), 104–108.)

3.2. Temporal habitat utilization

The exploitation of resources used by Guizhou golden monkey varied significantly by elevation among seasons (Kruskal-Wallis, $X^2 = 9.746$, $df = 3$, $p < 0.05$). From January to March (Spring), the elevational range (537–668 m) and daily distance travel (5200–7000 m) was greatest. In contrast during the summer and fall (April to September), the two seasons have the

Table 3
Monthly distribution of Guizhou golden monkey at the FNNR from September 2011 to August 2013.

Month Elevation (m)	1	2	3	4	5	6	7	8	9	10	11	12	group occurrence
1400–1500 m	3	0	0	0	0	0	0	0	0	0	0	0	3
1500–1600 m	4	4	5	12	6	0	0	7	8	6	1	6	59
1600–1700 m	4	8	6	9	8	0	3	4	4	3	6	7	62
1700–1800m	4	4	5	5	4	5	6	15	4	3	6	9	70
1800–1900m	2	2	5	5	6	15	8	2	7	7	7	7	73
1900–2000m	4	4	6	0	0	1	1	0	6	7	9	7	45
2000–2100 m	3	3	2	0	0	0	0	0	0	0	2	1	11

The group occurrence is the number of times that monkeys appear at different altitudes every month. As long as the monkeys are found feed and rest, the altitude is recorded.

Table 4
Monthly variation in elevational range and maximum daily move distance, September 2011 to August 2013.

Month	Frequency of monkey activity	Mean elevation(m)	SD[a]	Minimum elevation(m)	Maximum elevation(m)	Elevational range(m)[b]	Maximum daily move distance(m)	Minimum daily move distance(m)	SD[a]
1	24	1730	210	1432	2100	668	6000	5400	147
2	25	1680	173	1560	2100	540	6200	5200	369
3	29	1799	161	1503	2040	537	7000	6100	242
4	31	1645	113	1510	1876	366	1800	1000	226
5	24	1764	109	1543	1887	344	1000	550	119
6	21	1812	44	1756	1900	144	2000	1200	229
7	18	1790	80	1654	1912	258	2000	1100	257
8	28	1757	106	1507	1805	298	3200	2600	160
9	29	1780	145	1524	1921	397	4000	3200	233
10	26	1824	156	1513	1979	466	4000	3500	146
11	31	1810	144	1590	2100	510	5200	4300	315
12	37	1773	140	1546	2000	454	6000	5100	274
Spring	78	1736	176	1432	2100	668	7000	5200	493
Summer	76	1744	122	1510	1900	390	2000	550	426
Fall	75	1764	121	1507	1921	414	4000	1100	820
Winter	94	1800	147	1513	2100	587	6000	3500	739

[a] Standard deviation.
[b] Highest elevation minus lowest elevation in any month.

lowest elevational range of 144 m and the lowest daily move distance of 550 m. From October to December (winter), the elevational range and daily distance travel gradually increased (Table 4).

3.3. Vegetation distribution

We identified 236 species from 125 genera and 72 families in the 100 botanical plots, this included 183 tree species (75 genera and 42 families) and 53 vine species from 26 genera and 16 families (Table 5). The Shannon-Wiener diversity and evenness indices for each vegetation community were higher at elevations at 1700 m and 1900 m ($H = 5.97$ nit, $E = 0.85$, $H = 5.70$ nit, $E = 0.87$) and lower at elevations of 1500- m and 2100 m ($H = 5.24$ nit, $E = 0.82$; $H = 4.64$ nit, $E = 0.83$).

3.4. Food resource distribution within the range of elevational activity

3.4.1. Food species

The monkeys were observed to feed on a total of 104 species from 51 genera and 31 families (Table 6). This included 84 tree species from 41 genera and 26 families, representing 45.9% of the total number of tree species, and 20 vine species from 10 genera and 7 families, representing 37.7% of the total vine species. The IVI percentages of the feeding trees species at various elevations were: 65.5% at 1500 m, 65.6% at 1700 m, 72.9% at 1900 m, and 58.7% at 2100 m. The IVI percentage of feeding trees accounted for 66.4% of the total number of records in the plots (Table 6).

3.4.2. Food availability

The plant species consumed by the Guizhou golden monkey varied significantly among seasons. (Kruskal-Wallis, $X^2 = 8.897$, $df = 3$, $p < 0.05$). From January to March, 34 feeding trees species accounting for 32.7% of the diet were consumed, mainly the buds of *Pterostyrax psilophyllus, Prunus grayana, Carpinus kweichowensis, Betula austrosinensis, Styrax japonica, Sassafras tzumu* and *Acer flabellatum;* From April to June, 64 feeding trees species accounting for 61.5% of the diet were consumed, mainly the leaves of *Tilia tuan, Prunus grayana, Styrax faber, Cyclobalanopsis gracilis, Cladrastis sinensi, Sorbus*

Table 5
Woody and vine plants observed in various botanical plots.

Family	Species	Relative density (%)	Relative frequency (%)	Relative coverage (%)	IVI
Fagaceae	*Cyclobalanopsis stewardiana*	6.56	2.47	11.6	20.63
Fagaceae	*C. argyrotricha*	7.2	1.74	5.56	14.5
Fagaceae	*C. multinervis*	4.73	4.02	5.02	13.77
Betulaceae	*Betula austrosinensis*	3.08	2.83	5.59	11.49
Aceraceae	*Acer flabellatum*	2.98	2.19	4.26	9.43
Fagaceae	*Fagus longipetiolata*	2.82	1.65	5.34	9.81
Fagaceae	*Lithocarpus cleistocarpus*	1.5	1.64	3.06	6.21
Ericaceae	*Rhododendron ririei*	2.65	1	2.53	6.18
Styracaceae	*Pterostyrax psilophyllus*	1.2	1.64	2.85	5.69
Comaceae	*Bothrocaryum controversum*	1.96	1.64	1.81	5.41
Fagaceae	*Quercus engleriana*	1.35	1.92	2.12	5.39
Theaceae	*Eurya oblonga*	2.62	1.74	0.75	5.11
Rosaceae	*Cerasus serrulata*	1.3	1.19	2.43	4.91
Fagaceae	*Fagus lucida*	1.3	1	2.44	4.74
Rosaceae	*Cerasus dielsiana*	1.25	0.91	2.3	4.46
Betulaceae	*Carpinus viminea*	1.63	0.91	1.87	4.41
Clethraceae	*Clethra cavaleriei*	2.11	1.74	0.54	4.39
Aquifoliaceae	*Ilex fargesii*	1.53	1.64	1.12	4.29
Symplocaceae	*Symplocos phyllocalyx*	1.53	2.01	0.63	4.17
Rosaceae	*Padus brachypoda*	1.07	1.37	1.71	4.15
Theaceae	*Schima sinensis*	1.07	1.28	1.5	3.85
Ericaceae	*Enkianthus serrulatus*	1.91	1.28	0.59	3.78
Lauraceae	*Sassafras tzumu*	0.76	1.1	1.82	3.68
Rosaceae	*Padus obtusata*	0.81	0.91	1.83	3.56
Rosaceae	*Sorbus folgneri*	0.86	1.64	0.79	3.3
Rosaceae	*Cerasus clarofolia*	1.17	1	1.07	3.24
Lauraceae	*Lindera fruticosa*	1.53	1.1	0.54	3.16
Theaceae	*Camellia pitardii*	1.53	1.1	0.41	3.03
Aceraceae	*Acer davidii*	1.04	1.28	0.64	2.96
Aceraceae	*Acer oliverianum*	0.99	0.91	0.87	2.78
Lauraceae	*Litsea pedunculata*	0.84	1.37	0.56	2.77
Aceraceae	*Acer sinense*	0.71	1.28	0.53	2.52
Tetracentraceae	*Tetracentron sinense*	0.46	1	1.04	2.5
Rosaceae	*Sorbus xanthoneura*	0.69	0.91	0.87	2.47
Lauraceae	*Machilus chuanchienensis*	0.84	1.19	0.44	2.47
Comaceae	*Dendrobenthamia angustata*	0.97	0.91	0.58	2.46
Symplocaceae	*Symplocos sumuntia*	0.81	1.28	0.25	2.34
Aceraceae	*Acer maximowiczii subsp. porphyrophyllum*	0.43	0.91	0.87	2.22
Betulaceae	*Carpinus tschonoskii*	0.59	0.46	1.18	2.22
Magnoliaceae	*Magnolia sprengeri*	0.56	0.82	0.8	2.18
Oleaceae	*Fraxinus floribunda*	0.48	0.91	0.72	2.12
Rosaceae	*Ceraus serrula*	0.84	0.73	0.55	2.12
Aquifoliaceae	*Ilex bioritsensis*	0.66	1	0.37	2.03
Staphyleaceae	*Euscaphis japonica*	0.56	1.19	0.28	2.03
Rosaceae	*Sorbus keissleri*	0.69	0.73	0.5	1.91
Ericaceae	*Rhododendron siderophyllum*	0.94	0.64	0.32	1.9
Betulaceae	*Carpinus polyneura*	0.86	0.73	0.29	1.89
Theaceae	*Schima grandiperulata*	0.59	0.91	0.39	1.89
Theaceae	*Camellia cuspidata*	0.94	0.64	0.29	1.87
Theaceae	*Eurya nitida*	0.76	0.91	0.19	1.87
Rosaceae	*Photinia beauverdiana*	0.81	0.82	0.19	1.83
Ericaceae	*Rhododendron auriculatum*	0.66	0.64	0.51	1.81
Theaceae	*Eurya brevistyla*	0.69	0.91	0.17	1.77
Ericaceae	*Rhododendron haofui*	0.66	0.55	0.53	1.74
Clethraceae	*Clethra fargesii*	0.76	0.64	0.33	1.74
Betulaceae	*Betula insignis*	0.56	0.73	0.42	1.71
Betulaceae	*Corylus ferox Wall. var. thibetica*	0.56	0.73	0.37	1.66
Caprifoliaceae	*Weigela japonica*	0.61	0.91	0.13	1.65
Ericaceae	*Rhododendron bachii*	0.81	0.46	0.2	1.48
Leguminosae	*Cladrastis sinensis*	0.36	0.46	0.59	1.41
Magnoliaceae	*Illicium simonsii*	0.38	0.91	0.11	1.4
Lauraceae	*Litsea cubeba*	0.59	0.73	0.09	1.4
Fagaceae	*Cyclobalanopsis gambleana*	0.59	0.27	0.51	1.37
Anacardiaceae	*Rhus chinensis*	0.48	0.73	0.15	1.36
Daphniphyllaceae	*Daphniphyllum macropodum*	0.36	0.64	0.37	1.36
Aquifoliaceae	*Ilex corallina*	0.41	0.64	0.3	1.35
Aceraceae	*Acer franchetii*	0.36	0.64	0.33	1.33
Ericaceae	*Enkianthus chinensis*	0.53	0.55	0.23	1.31
Theaceae	*Eurya semiserrata*	0.71	0.37	0.16	1.24
Lauraceae	*Litsea ichangensis*	0.36	0.73	0.14	1.23

Table 5 (*continued*)

Family	Species	Relative density (%)	Relative frequency (%)	Relative coverage (%)	IVI
Ericaceae	*Enkianthus chinensis*	0.51	0.55	0.13	1.19
Cephalotaxaceae	*Cephalotaxus sinensis*	0.59	0.37	0.18	1.13
Symplocos	*Symplocos anomala*	0.31	0.73	0.1	1.13
Ericaceae	*Vaccinium bracteatum*	0.38	0.64	0.06	1.09
Saxifragaceae	*Hydrangea xantnoneura*	0.28	0.64	0.11	1.03
Clethraceae	*Clethra cavaleriei*	0.25	0.55	0.15	0.95
Anacardiaceae	*Toxicodendron succedaneum*	0.15	0.46	0.32	0.93
Magnoliaceae	*Illicium lanceolatum*	0.46	0.37	0.06	0.89
Rutaceae	*Evodia fargesii*	0.15	0.18	0.54	0.87
Nyssaceae	*Davidia involucrata*	0.18	0.18	0.42	0.78
Cercidiphyllaceae	*Cercidiphyllum japonicum*	0.13	0.09	0.53	0.75
Ericaceae	*Rhododendron stamineum*	0.36	0.27	0.11	0.74
Styracaceae	*Styrax hemsleyanus*	0.23	0.27	0.2	0.71
Comaceae	*Dendrobenthamia japonica*	0.33	0.27	0.1	0.7
Fagaceae	*Castanea henryi*	0.08	0.18	0.43	0.69
Ericaceae	*Rhododendron longesquamatum*	0.18	0.27	0.24	0.69
Juglandaceae	*Cyclocarya paliurus*	0.23	0.27	0.18	0.69
Oleaceae	*Fraxinus huangshanensis*	0.23	0.27	0.18	0.69
Celastraceae	*Euonymus myrianthus*	0.15	0.46	0.06	0.67
Aquifoliaceae	*Ilex wilsonii*	0.25	0.27	0.1	0.63
Ericaceae	*Rhododendron concinnum*	0.13	0.37	0.13	0.62
Pinaceae	*Tsuga longibracteata*	0.05	0.09	0.47	0.62
Ericaceae	*Pieris formosa*	0.41	0.18	0.02	0.61
Rosaceae	*Sorbus caloneura*	0.18	0.27	0.15	0.6
Oleaceae	*Ligustrum quihoui*	0.15	0.37	0.08	0.59
Rosaceae	*Sorbus wilsoniana*	0.15	0.37	0.06	0.58
Flacourtiaceae	*Idesia polycarpa*	0.13	0.37	0.08	0.57
Euphorbiaceae	*Mallotus japonicus var. floccosus*	0.13	0.37	0.08	0.57
Aceraceae	*Acer nayongense*	0.15	0.27	0.11	0.53
Araliaceae	*Acanthopanax evodiaefolius*	0.1	0.37	0.06	0.53
Lauraceae	*Actinodaphne omeiensis*	0.13	0.37	0.03	0.52
Leguminosae	*Sophora japonica*	0.05	0.18	0.29	0.52
Oleaceae	*Fraxinus sikkimensis*	0.15	0.27	0.06	0.49
Rosaceae	*Sorbus megalocarpa*	0.13	0.18	0.17	0.48
Ericaceae	*Rhododendron fortunei*	0.13	0.18	0.15	0.46
Taxaceae	*Taxus chinensis*	0.1	0.27	0.08	0.45
Tiliaceae	*Tilia tuan*	0.05	0.18	0.22	0.45
Lauraceae	*Litsea elongata var. faberi*	0.15	0.27	0.02	0.45
Ericaceae	*Rhododendron rufum*	0.13	0.18	0.13	0.44
Hamamelidaceae	*Liquidambar formosana var. monticola*	0.08	0.27	0.09	0.44
Oleaceae	*Eurya serrulata*	0.2	0.18	0.04	0.43
Rosaceae	*Malus yunnanensis*	0.1	0.18	0.13	0.41
Clethraceae	*Clematoclethrakaipoensis*	0.15	0.18	0.08	0.41
Rosaceae	*Malus yunnanensis var. veitchii*	0.13	0.18	0.1	0.41
Oleaceae	*Fraxinus floribunda*	0.08	0.27	0.05	0.4
Aquifoliaceae	*Ilex ficoidea*	0.08	0.27	0.05	0.4
Ericaceae	*Enkianthus deflexus*	0.2	0.09	0.1	0.39
Styracaceae	*Styrax japonicus*	0.08	0.18	0.09	0.35
Oleaceae	*Fraxinus chinensis*	0.13	0.09	0.12	0.34
Rosaceae	*Prunus serrulata*	0.1	0.09	0.14	0.33
Theaceae	*Stewartia sinensis*	0.08	0.09	0.16	0.33
Aquifoliaceae	*Ilex pedunculosa*	0.08	0.18	0.06	0.32
Salicaceae	*Populus adenopoda*	0.05	0.18	0.08	0.31
Betulaceae	*Corylus heterophylla*	0.05	0.18	0.06	0.3
Aceraceae	*Acer erianthum*	0.08	0.18	0.03	0.29
Fagaceae	*Cyclobalanopsis gracilis*	0.08	0.18	0.03	0.29
Hippocastanaveae	*Aesculus wilsonii*	0.05	0.18	0.05	0.29
Aceraceae	*Acer henryi*	0.08	0.09	0.12	0.29
Aceraceae	*Acer erianthum*	0.03	0.18	0.08	0.29
Clethraceae	*Clethra kaipoensis*	0.13	0.09	0.06	0.28
Fagaceae	*Fagus engleriana*	0.1	0.09	0.09	0.28
Aquifoliaceae	*Ilex szechwanensis*	0.05	0.18	0.04	0.28
Hamamelidaceae	*Corylopsis veitchiana*	0.08	0.18	0.01	0.27
Betulaceae	*Carpinus kweichowensis*	0.1	0.09	0.08	0.27
Betulaceae	*Carpinus tschonoskii*	0.05	0.18	0.03	0.27
Olacaceae	*Schoepfia jasminodora*	0.05	0.18	0.03	0.27
Caprifoliaceae	*Viburnum setigerum*	0.08	0.18	0	0.26
Betulaceae	*Betula luminifera*	0.05	0.18	0.02	0.26
Ericaceae	*Rhododendron beesianum*	0.08	0.09	0.08	0.24
Symplocaceae	*Symplocos laurina*	0.05	0.09	0.1	0.24

(*continued on next page*)

Table 5 (*continued*)

Family	Species	Relative density (%)	Relative frequency (%)	Relative coverage (%)	IVI
Lauraceae	*Neolitsea wushanica*	0.05	0.18	0	0.23
Theaceae	*Camellia cuspidata*	0.13	0.09	0.01	0.23
Caprifoliaceae	*Viburnum dilatatum*	0.05	0.09	0.09	0.23
Rosaceae	*Sorbus aronioides*	0.1	0.09	0.03	0.23
Theaceae	*Camellia cuspidata*	0.1	0.09	0.01	0.2
Rosaceae	*Padus racemosa*	0.09	0.09	0.03	0.2
Hamamelidaceae	*Liquidambar acalycina*	0.03	0.09	0.08	0.19
Ericaceae	*Rhododendron argyrophyllum*	0.05	0.09	0.04	0.19
Pinaceae	*Pinus massoniana*	0.05	0.09	0.03	0.17
Aquifoliaceae	*Ilex chinensis*	0.03	0.09	0.05	0.17
Lauraceae	*Litsea veitchiana*	0.05	0.09	0.02	0.16
Rosaceae	*Stranvaesia amphidoxa*	0.05	0.09	0.01	0.15
Hamamelidaceae	*Liquidambar formosana*	0.03	0.09	0.03	0.15
Juglandaceae	*Platycarya strobilacea*	0.03	0.09	0.03	0.15
Cephalotaxaceae	*Cephalotaxus fortunei*	0.03	0.09	0.03	0.15
Caprifoliaceae	*Viburnum henryi*	0.05	0.09	0	0.14
Rosaceae	*Prunus pilosiuscula*	0.02	0.09	0.03	0.14
Caprifoliaceae	*Viburnum fordiae*	0.05	0.09	0	0.14
Hamamelidaceae	*Corylopsis sinensis*	0.05	0.09	0	0.14
Nyssaceae	*Nyssa sinensis*	0.03	0.09	0.02	0.14
Sabiaceae	*Meliosma myriantha*	0.03	0.09	0.02	0.14
Theaceae	*Eurya impressinervis*	0.03	0.09	0.01	0.13
Ericaceae	*Rhododendron brevinerve*	0.03	0.09	0.01	0.13
Ericaceae	*Rhododendron sutchuenense*	0.03	0.09	0.01	0.13
Sabiaceae	*Meliosma flexuosa*	0.03	0.09	0.01	0.13
Pinaceae	*Tsuga chinensis*	0.03	0.09	0.01	0.13
Lauraceae	*Litsea elongata*	0.03	0.09	0.01	0.13
Anacardiaceae	*Toxicodendron sylvestre*	0.03	0.09	0.01	0.13
Aceraceae	*Acer laxiflorum*	0.03	0.09	0.01	0.13
Polygonaceae	*Polygonum vaccinifolium*	0.03	0.09	0.01	0.13
Rubiaceae	*Emmenopterys henryi*	0.03	0.09	0.01	0.13
Caprifoliaceae	*Viburnum sympodiale*	0.03	0.09	0	0.12
Caprifoliaceae	*Viburnum betulifolium*	0.03	0.09	0	0.12
verbenaceae	*Clerodendurm trichotomum*	0	0.09	0.03	0.12
Rosaceae	*Padus grayana*	0.03	0.09	0	0.12
Styracaceae	*Styrax faberi*	0.03	0.09	0	0.12
Theaceae	*Eurya aurea*	0.03	0.09	0	0.12
Ebenaceae	*Diospyros lotus*	0.03	0.09	0	0.12
Symplocaceae	*Symplocos stellaris*	0.03	0.09	0	0.12
Leguminosae	*Dalbergia balansae*	0.03	0.09	0	0.12
Lauraceae	*Lindera obtusiloba*	0.03	0.09	0	0.12
Aquifoliaceae	*Ilex atrata var. wangii*	0.03	0.09	0	0.12
Lauraceae	*Lindera communis*	0.03	0.09	0	0.12
Rhamnaceae	*Berchemia kulingensis*				
Liliaceae	*Smilax discotis*				
Saxifragaceae	*Hydrangea anomala*				
Rosaceae	*Rubus caudifolius*				
Celastraceae	*Calestrus vaniotii*				
Caprifoliaceae	*Lonicera acuminata*				
Actinidiaceae	*Actinidia rubricaulis*				
Actinidiaceae	*Actinidia laevissima*				
Actinidiaceae	*Actinidia callosa*				
Actinidiaceae	*Actinidia chinensis*				
Actinidiaceae	*Actinidia melanandra*				
Actinidiaceae	*Actinidia sorbifolia*				
Actinidiaceae	*Actinidia chinensis*				
Celastraceae	*Celastrus hypoleucus*				
Saxifragaceae	*Schizophragma integrifolium*				
Celastraceae	*Tripterygium hypoglaucum*				
Loganiaceae	*Gelsemium elegans*				
Vitaceae	*Parthenocissus semicordata*				
Vitaceae	*Vitis heyneana*				
Lardizabalaceae	*Holboellia coriacea*				
Ranunculaceae	*Clematis lasiandra*				
Vitaceae	*Vitis wilsonae*				
Saxifragaceae	*Schizophragma integrifolium var. glaucescens* Rehd				
Caprifoliaceae	*Lonicera gynochlamydea*				
Rosaceae	*Rosa sertata*				
Moraceae	*Ficus virens* Ait. *var. sublanceolata*				
Lardizabalaceae	*Akebia trifoliata*				
Vitaceae	*Vitis heyneana*				

Table 5 (*continued*)

Family	Species	Relative density (%)	Relative frequency (%)	Relative coverage (%)	IVI
Caprifoliaceae	*Lonicera pileata*				
Leguminosae	*Sphaerophysa salsula*				
Elaeagnaceae	*Elaeagnus bockii*				
Sabiaceae	*Sabia swinhoei*				
Loranthaceae	*Scurrula parasitica*				
Lardizabalaceae	*Akebia trifoliata*				
Celastraceae	*Euonymus fortunei*				
Elaeagnaceae	*Elaeagnus difficilis*				
Vitaceae	*Ampelopsis bodinieri*				
Lardizabalaceae	*Holboellia latifolia*				
Saxifragaceae	*Pileostegia viburnoides*				
Vitaceae	*Ampelopsis delavayana*				
Dioscoreaceae	*Dioscorea opposita*				
Liliaceae	*Smilax stans*				
Magnoliaceae	*Schisandra henryi*				
Araliaceae	*Hedera nepalensis*				
Lardizabalaceae	*Holboellia grandiflora*				
Actinidiaceae	*Clematoclethra lasioclada*				
Magnoliaceae	*Kadsura heteroclita*				
Liliaceae	*Smilax china*				
Magnoliaceae	*Kadsura longipedunculata*				
Celastraceae	*Celastrus gemmatus*				
Loranthaceae	*Taxillus sutchuenensis*				
Lardizabalaceae	*Sargentodoxa cuneata*				
Magnoliaceae	*Kadsura coccinea*				

wilsoniana and fruits of *Prunus grayana*. From July to September, 81 feeding trees species accounting for 77.9% of the diet were consumed, mainly the leaves of *Prunus grayana, Tilia, Litsea cubeba, Styrax japonica* and the fruits of *Dendrobenthamia and Acer davidii*. Finally, from October to December, 52 feeding trees species accounting for 50% of the diet were consumed, mainly the fruits and seeds of *Dendrobenthamia, Cerasus serrulata*, *Sorbus megalocarpa, Camellia* and the buds of *Magnolia sprengeri.* The monkeys fed on a core set of 28 species during all seasons the year, which accounted for 15.3% of the total number of species consumed (Table 4). In addition, 48 species were consumed during at least 2 seasons of the year.

3.5. Altitudinal activity and food availability

Across different seasons, the Guizhou golden monkey used different species and various parts of those species. Meanwhile, the elevation activity range and daily movement distance were also different. From January to March, due to the limited food availability, the monkeys mainly used buds as their food, and elevation range (537–668 m) and daily move distance (6000–7000 m) was the Maximum. From April to September, food resources are more abundant, as the number of edible plants gradually increases, and the range of elevation (144–397 m) and daily movement distance (1000–4000 m) gradually decreased. From October to December, the leaves begin to fall, consequently the range of elevation (454–510 m) and daily distance of movement (4000–6000 m) of monkeys began to gradually increase again (Fig. 2; Fig. 3).

3.6. Correlation between activity frequency and food resource abundance

During all seasons of the year, the frequency that we observed Ghizhou golden monkeys at particular elevations was positively correlated with the total number of woody plant species, total number of feeding trees, and coverage ($r = 0.900$, P (two-tailed) < 0.05; $r = 0.900$, $p < 0.05$; $r = 0.900$, $P < 0.05$, respectively) at these elevations. This implies that monkeys' ranging patters were based principally on the temporal and spatial availability of feeding sites. Relatedly, the frequency of group occurrence was positively correlated with the number of individuals and plant species and IVI percentage of food resources ($r = 0.900$, $P < 0.05$; $r = 0.900$, $P < 0.05$; $r = 0.900$, $P < 0.05$, respectively).

4. Discussion

4.1. Altitudinal activity

Based on the findings of the present study, an activity mainly range for Guizhou golden monkeys was determined as being between 1500 m and 2100 m, mainly attributable to the abundance of food resources. These results are in agreement with previous behavioral observations of Quan and Xie (2002). Guizhou golden monkey are rarely active in regions with elevations below 1500 m and not active above 2100 m. Vegetation in the northeastern and northwestern of FNNR, which is situated at elevations below 1500 m, has been severely damaged by human activity. Although the some of the vegetation is well

Table 6
Food species and plant parts consumed by *Rhinopithecus brelichi*, September 2011 to August 2013.

Family	Genus	Species	Elevation	Parts	Month
Fagaceae	*Cyclobalanopsis*	*Cyclobalanopsis argyrotricha*	1500–1900	Buds, leaves, seeds	Whole year
		Cyclobalanopsis gambleana	1500–1700	Buds, leaves, seeds	Whole year
		Cyclobalanopsis gracilis	1500–1900	Buds, leaves, seeds	Whole year
		Cyclobalanopsis multinervis	1500–1900	Buds, leaves, seeds	Whole year
	Fagus	*Fagus lucida*	1500–1900	Buds, leaves	Whole year
		Fagus longipetiolata	1500–1900	Bud, leaves	Whole year
	Lithocarpus	*Lithocarpus cleistocarpus*	1500–2100	Leaves	October–December
	Castanea	*Castanea henryi*	1500–1700	Leaves	October–December
	Quercus	*Quercus engleriana*	1500–2100	Leaves	October–December
Betulaceae	*Betula*	*Betula austrosinensis*	1500–2100	Leaves	October–December
		Betula luminifera	1700	Buds, leaves	December–March
	Carpinus	*Carpinus viminea*	1500–1700	Buds	December–March
		Carpinus kweichowensis	1500	Buds	December–March
		Carpinus polyneura Franch.	1700–1900	Buds	December–March
		Carpinus tschonoskii	1700	Buds	December–March
		Carpinus falcatibracteata	1500–1900	Buds	December–March
Leguminosae	*Cladrastis*	*Cladrastis sinensis*	1500–1900	Leaves, flowers	December–March
Lauraceae	*Litsea*	*Litsea cubeba*	1700–2100	Leaves, flowers, seeds	Whole year
		Litsea ichangensis	1500–1900	Leaves, seeds	April–September
		Litsea elongata var. faberi	1700–1900	Leaves, seeds	April–September
		Litsea pedunculata	1700–2100	Leaves, seeds	April–September
	Lindera	*Lindera fruticosa*	1500–2100	Leaves	July
	Sassafras	*Sassafras tzumu*	1500–1700	Buds	January–March
Aceraceae	*Acer*	*Acer flabellatum*	1700–2100	Buds, Leaves	Whole year
		Acer davidii	1500–1900	Buds, Leaves	Whole year
		Acer sinense	1500–1900	Buds, Leaves	Whole year
		Acer franchetii	1700–2100	Buds, Leaves	Whole year
Ericaceae	*Rhododendron*	*Rhododendron ririei*	1700–2100	Flowers	April–May
		Rhododendron siderophyllum	1700–2100	Flowers	April–May
		Rhododendron auriculatum	1700–2100	Flowers	April–May
		Rhododendron haofui	1500–1700	Flowers	April–May
		Rhododendron longesquamatum	1700–2100	Flowers	April–May
		Rhododendron fortunei	2100	Flowers	April–May
		Rhododendron rufum	1500–1700	Flowers	April–May
		Rhododendron beesianum	1900	Flowers	April–May
		Rhododendron stamineum	1500–1700	Flowers	April–May
Styracaceae	*Pterostyrax*	*Pterostyrax psilophyllus*	1700–1900	Buds, leaves	Whole year
	Styrax	*Styrax japonicus*	1700–1900	Leaves	Whole year
		Styrax faberi	1500	Leaves	Whole year
Comaceae	*Bothrocaryum*	*Bothrocaryum controversum*	1500–2100	Leaves, seeds	Whole year
	Dendrobenthamia	*Dendrobenthamia angustata*	1500–1900	Fruits	September–October
Rosaceae	*Cerasus*	*Cerasus serrulata*	1700–2100	Buds, leaves, fruits	Whole year
		Ceraus serrula	1700–2100	Buds, leaves, fruits	Whole year
		Cerasus clarofolia	1900–2100	Buds, leaves, fruits	Whole year
		Cerasus dielsiana	1700–2100	Buds, leaves, fruits	Whole year
	Padus	*Padus brachypoda*	1500–2100	Buds, leaves	Whole year
		Prunus grayana	1700–1900	Buds, leaves	Whole year
		Padus obtusata	1700–2100	Buds, leaves	Whole year
	Sorbus	*Sorbus folgnei*	1500–1700	Fruits	October
		Sorbus aronioides	1500–1700	Fruits	October
		Sorbus megalocarpa	1900	Fruits	October
		Sorbus wilsoniana	1700–1900	Leaves, fruits	May, July, October
		Sorbus xanthoneura	1700–2100	Leaves, fruits	May, July, October
		Sorbus keissleri	1700–2100	Fruits	October
	Photinia	*Photinia beauverdiana*	1500–1900	Leaves, fruits	May, July, October
Aquifoliaceae	*Ilex*	*Ilex fargesii*	1,500, 1900–2100	Leaves	October–March
		Ilex pedunculosa	1700–1900	Leaves	October–March
		Ilex szechwanensis	1,700, 2100	Leaves	October–March
		Ilex bioritsensis	1900–2100	Leaves	October–March
		Ilex wilsonii	1,700, 2100	Leaves	October–March
		Ilex ficoidea	1500–1900	Leaves	October–March
Symplocaceae	*Symplocos*	*Symplocos phyllocalyx*	1500–2100	Buds, leaves	Whole year
		Symplocos sumuntia	1500–1900	Buds, leaves	Whole year
		Symplocos anomala	1500–1900	Buds, leaves	Whole year
Theaceae	*Schima*	*Schima sinensis*	1700–2100	Leaves	October–December
		Schima grandiperulata	1900	Leaves	October–December
	Camellia	*Camellia pitardii*	1500–1900	Buds, leaves, fruits	Whole year
		Camelia cuspitada	1500–1900	Fruits	September–October

Table 6 (*continued*)

Family	Genus	Species	Elevation	Parts	Month
	Eurya	*Eurya semiserrata*	1700–1900	Leaves	April–July
Tetracentraceae	*Tetracentron*	*Tetracentron sinense*	1700–2100	Leaves	October–March
Magnoliaceae	*Magnolia*	*Magnolia sprengeri*	1500–1900	Buds, leaves	Whole year
	Ligustrum	*Ligustrum quihoui*	1900	Leaves	October–December
Staphyleaceae	*Euscaphis*	*Euscaphis japonica*	1500–1700	Leaves	October–December
Daphniphyllaceae	*Daphniphyllum*	*Daphniphyllum macropodum*	1500–1700	Leaves	January–March
Rutaceae	*Evodia*	*Evodia fargesii*	1700–1900	Leaves	October–December
Nyssaceae	*Davidia*	*Davidia involucrata*	1700–1900	Leaves, Fruits	July–October
Celastraceae	*Euonymus*	*Euonymus myrianthus*	1500	Buds, leaves	January–March, October –December
Tiliaceae	*Tilia*	*Tilia tuan*	1500–1700	Buds, leaves	Whole year
Hamamelidaceae	*Liquidambar*	*Liquidambar formosana var. monticola*	1500–1700	Leaves	October–December
Caprifoliaceae	*Viburnum*	*Viburnum setigerum*	1700–1900	Leaves	August–October
		Viburnum betulifolium	1700–1900	Leaves	August–October
		Viburnum fordiae	1900	Leaves	August–October
		Viburnum sympodiale	2100	Leaves	August–October
Elaeagnaceae	*Elaeagnus*	*Elaeagnus difficilis*	1500–1700	Leaves	October–December

preserved, it mainly comprises hardwood broad-leaved forest, which is not a dietary resource for Guizhou golden monkey (Quan and Xie, 2002). This forest predominantly comprises *Castanopsis carlesii*, *Castanopsis fargesii*, *Machilus pingii*, and other Lauraceae and Fagaceae species. The installation of a tourist ropeway system in the south part of the reserve has severely curtailed monkey activity (Quan and Xie, 2002). The vegetation at elevations above 2100 m is primarily alpine shrub meadows and conifer forests, which include plants that are rarely consumed by monkeys and offers little cover.

4.2. Plant food selection and diversity

Vegetation between 1500 m and 2100 m contributes most of the food resources for the Guizhou golden monkey. Previous studies by Bleisch and Xie (1998), Xie & Quan (2002), and Yang and Emily, 2002 reported that the primary plant food

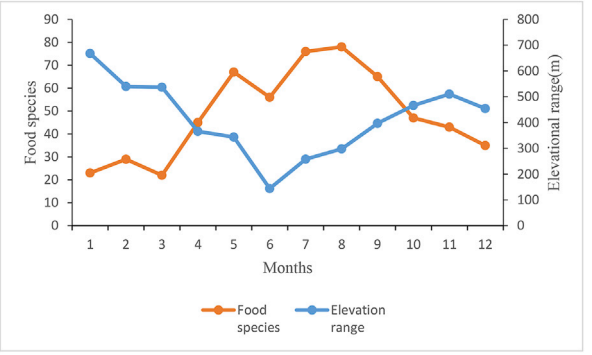

Fig. 2. Guizhou golden monkey's Food species and elevational range in different. months, September 2011 to August 2013.

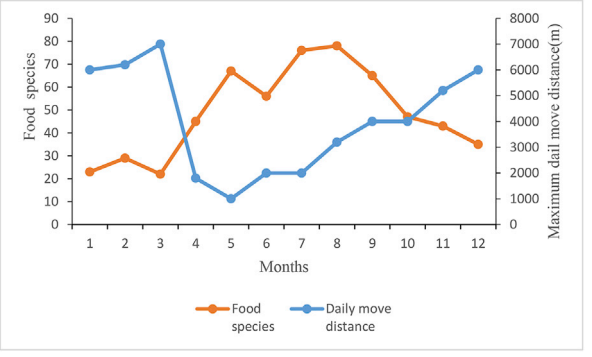

Fig. 3. Guizhou golden monkey's Food species and maximum dailly move distance. in different months, September 2011 to August 2013.

resources comprise of six species, which include *Pterostyrax psilophyllus, Prunus vaniotii, Magnolia sprengeri, Acer flabellatum, Sorbus xanthoneura*, and *Cornus elliptica*. our result shows that these six species are distributed at 1700 m and 1900 m, included 111 trees (6.7% of the amount) and 129 trees (11.0% of the amount), respectively, whereas at elevation levels of 1500 m and 2100 m, there were 27 trees (4.4% of the amount) and 53 trees (9.7% of the amount), respectively, of which *Acer flabellatum, Pterostyrax psilophyllus, Sorbus xanthoneura,* and *Magnolia sprengeri* were used as food for the entire year. Different parts of the 28 whole-year feeding plants were eaten during different seasons. These findings imply that the areas within the elevation range of 1500 m to 2100 m provided the main food resources that supply the feeding requirements of monkeys during different seasons. It was especially at the elevation levels of 1700 m and 1900 m, with the highest species diversity index, that provide more food resources for the Guizhou golden monkey, and this range had the highest frequency of monkey group activity throughout the year.

4.3. Habitat utilization

Previous research on the elevation activities range of Guizhou golden monkey indicated that the monkeys used areas between 1350 and 1,870 m, at Yangaoping where a significant difference in the mean elevations among seasons was not observed (Niu et al., 2010). These studies only used point count estimates using a stable observation point, so the sampling range was necessarily limited. However, our research recorded the elevation of annual activity of Guizhou golden monkey using field follows. Our results show that the range of elevation activity is wider and is likely to be more accurate due to the field methods used. That the Guizhou golden monkey feeds on different plants and plant parts in different seasons is consistent with the method of Xiang et al. (2012). Our study further found that the range of elevation activity of the monkeys varied as a function of seasonal foraging activity. Variation in diet in response to seasonal changes have also been reported in *R. roxellana* and *R. bieti. R. roxellana* has a foraging strategy that seeks to balance energy budget and food quality, with a seasonal time budget of 36.8% spent moving and 15.2% time spent feeding in autumn, when food quality is highest, but 21.0% time spent moving and 65.6% time spent feeding in winter, when food quality is lowest from (Guo et al., 2007). Lichens form a major part of the diet of *R. bieti* throughout the year, and lichen choice serves as a key strategy for its survival, functioning as staple fallback food during seasonal shortages in preferred plant food items (Xiang et al., 2007b; Huang et al., 2017). In autumn, *R. bieti* feeds on high quality fruit, reduced its feeding time and increasing its time engaged in other activities. In winter, when food resources are lacking, 41.5% of their time was spent feeding, and 24.4% resting (Li et al., 2013). Similarly, the Guizhou golden monkey has a positive foraging strategy to obtain higher quality food. During the cold season the Guizhou golden monkey mainly on plant buds but buds are of lower quality than fruits, seeds, flowers, and leaves. In order to obtain higher quality food in a narrow habitat range, the Guizhou golden monkey needs to expand its range in vertical and horizontal activities, since it does not appear to have a staple fallback food. The Guizhou golden monkey also has different activity distribution in different seasons, with 11.67% time spent moving and 27.02% time spent feeding in Autumn and 22.0% time spent moving and 32.78% time spent feeding in winter (Xie and Quan 2002). Some studies have reported that the elevational range of *R. roxellana* (1500−3,300 m) and *R. bieti* (2600−4,000 m) is wider than the Guizhou golden monkey (Li, 2006; Li et al., 2008).

5. Conservation implications

The current results show that monkeys are active in regions with elevations above 1400 m. So, the conservation of existing habitat is crucial, human disturbance from tourism should be strictly controlled. My results suggest that different parts of the 28 whole-year feeding plants were eaten during different seasons, some of the dominant species with high elevation distribution are important food resources for the monkeys, such as *Acer flabellatum, Pterostyrax psilophyllus, Sorbus xanthoneura, and Magnolia sprengeri* and so on. So, we suggest artificially plant important food species to increase the food resources of the monkeys in different seasons. Meanwhile, the reserve should expand the activity range of monkeys, through artificial afforestation to restore forest vegetation and establish appropriate habitats for monkeys in areas under 1400 m.

Interests statement

No conflict of interest exits in the submission of this manuscript, and manuscript is approved by all authors for publication.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.gecco.2018.e00473.

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