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Original article

Dietary response of a group of François' langur *Trachypithecus francoisi* in a fragmented habitat in the county of Fusui, China: implications for conservation

Youbang Li, Ping Ding, Chengming Huang, Pingping Jiang & Chris Wood

François' langur *Trachypithecus francoisi* is a threatened monkey species whose populations have been declining rapidly during the last four decades, and at the same time, there has been a severe fragmentation of the species' habitat. Using focal animal sampling and continuous recording, we studied food selection of a group of François' langur in a small fragmented habitat in the county of Fusui, Guangxi Province, China. We also analysed the vegetation data obtained within their home range using quadrat sampling. The langurs consumed a higher proportion of leaves but from a smaller number of plant species than their conspecifics in continuous habitats. They selectively utilised specific species as food sources, and they spent 61.6% of their feeding time on four staple species, whilst only 38.4% of their feeding time was spent on the 36 plant species that were either seasonally or rarely consumed food items. Although our sample sizes were small and from a single group, our results suggest that, similar to other colobine species, François' langurs in a fragmented habitat are highly selective feeders. Although the langurs appeared reasonably tolerant and well adapted to cope with habitat fragmentation in the short-term, they are still to be considered as highly vulnerable as their survival depends on a small number of food plants, which themselves could be threatened by other factors.

Key words: food choice, François' langur, habitat fragmentation, Trachypithecus francoisi

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François' langur *Trachypithecus francoisi* is a threatened species (IUCN 2004) endemic to the Karst limestone landscape regions of the tropical and subtropical zones of southwestern China and northern Vietnam (Zhang et al. 1992, Canh 1996). Unfortunately, both their population size and habitat areas have been rapidly declining during the past four decades, mainly as a consequence of deforestation and hunting (Wu 1983, Wu et al. 1987, Liu & Wei 1995, Nadler et al. 2003, Hu et al. 2004). In Vietnam, for example, the remnant populations of approximately 180-280 individuals survive in only 10 isolated habitat fragments (Nadler et al. 2003). In Guangxi Province, China, during the 1980s, the François' langur was considered to be an extremely widespread primate species with a population size of

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4,500-5,000 and a distribution area of 23 counties, coinciding with the distribution of limestone landscapes in the southwest of Guangxi (Wu 1983, Wu et al. 1987, Zhang et al. 1992, Wang et al. 1999, Limestone Research Team of Guangxi Academy Institute 1994). By the mid-1990s, the population size was considered to have declined to 2,000-2,500, mainly isolated in 15 nature reserves in 13 counties (Liu & Wei 1995, Wang et al. 1999). The current extent of occurrence is now reported to consist of only 14 localities in 10 counties, and this represents a loss in 13 counties during a little more than one decade. The current population size of the François' langur in Guangxi is estimated at about 300. The remaining langur habitat has also become increasingly fragmented in as far as 56% of the individuals now occur in groups isolated within such fragmented habitats (Li et al. 2007). The 23 counties in which the François' langur occurred in the 1980s contain ca 31,390 km^2 of limestone hills, of which 8% are already considered degraded due to deforestation and burning in the 1980s. Degraded limestone areas in the early 1990s accounted for 60.0% of the original area (Limestone Research Team of Guangxi Academy Institute 1994).

As deforestation and habitat fragmentation continues at an alarming rate throughout the world, the survival of many forest species largely depends on their ability to cope with such changes (Noss & Csuti 1994, Onderdonk & Chapman 2000). Two major characteristics of primates may influence their ability to live in forest fragments. First, primate species need to either have a small home range or otherwise be able to move across the gaps between the isolated fragments of suitable habitat (Estrada & Coates-Estrada 1996, Onderdonk & Chapman 2000, Wong et al. 2006). Second, a highly frugivorous diet may limit the ability of species to live in fragments (Lovejoy et al. 1986, Estrada & Coates-Estrada 1996). The ability or inability of primates to adjust their feeding behaviour as their habitat changes becomes a key consideration. Members of the Alouattinae have the tendency to forage for more leaves when restricted to a smaller home range (Crockett 1998, Estrada et al. 1999), and the numbers of plant species and the quantity of fruits in their diets have been positively correlated to the size of their habitat (Bicca-Marques 2003). Whilst other specialists have argued that species with a more species diverse diet, such as e.g. black-and-white colobus *Colobus guereza*, and Geoffroy's black-and-white colobus or ursine colobus *C. vellerosus* might be more able to persist in fragments (Onderdonk & Chapman 2000, Wong et al. 2006). Monkeys have shown their ability to adjust to consume secondary growth, such as lianas, when few other dietary alternatives are present (Bicca-Marques 2003).

Our knowledge of François' langurs' dietary response to habitat fragmentation remains limited. It is therefore imperative that research efforts are focused on identifying how subpopulations utilise resources in these areas and whether, and to what extent, they are susceptible to extinction in forest fragments. Such information may be important for developing successful conservation plans. In our study, we analysed the diet composition of a group of François' langur in a fragmented and severely disturbed habitat. We compare our results to outcomes from studies on groups living in intact forests and discuss whether the François' langur can survive in forest patches and disturbed habitats.

Methods

Study site and study animals

Our study site is an isolated hilly area of about 25.7 ha (107°50'E, 22°45'N) in the county of Fusui, Province, China (Fig. 1). The site is characterised by limestone landscape with many steep cliffs, natural caves and overhangs. The natural caves are typical sleeping sites of François' langurs. The site is situated within a subtropical monsoon climate zone, i.e. temperatures are higher during the summers and water is abundant, whereas winters are cooler and dry (Cai 2004). The average annual precipitation is 1,054.3 mm (range: 1,022-1,769 mm). On average, 81.4% of the precipitation falls during the rainy season, when mean monthly precipitation is 171.7 mm (range: 123.7-228.7 mm). The average daily temperature is 22.1°C (range: -0.5°-+ 39.5°C), with the average monthly temperatures during the rainy and dry seasons being 25.2°C and 20.6°C, respectively. The study site has been isolated from forest on other hills by sugarcane plantations since 1960 (Y. Li, unpubl. data). The practice of selective firewood collection has removed larger trees, greatly altering the vegetation composition. Thus the vegetation is now characterised as secondary broadleaf forest (Xue 2000). Small remnants of forest remain along the steep slopes of hillsides that are difficult to farm. In total, 80% of the study site hill is covered by sparse trees, shrubs and grass (Y. Xue, unpubl. data). Viewing conditions were favourable.

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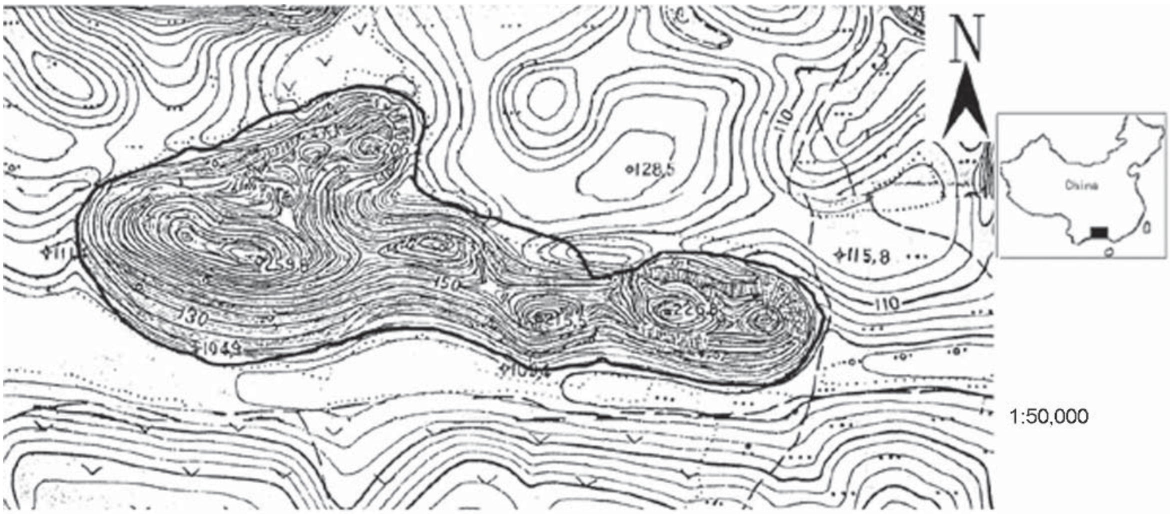

Figure 1. Location of the county of Fusui in China. In the study site, the limestone hills used by the langur group are outlined; 80% of the area is covered by sparse trees, shrubs and grass. The surrounding matrix is cultivated for sugarcane and cassava by local villagers.

The area supports a relatively well habituated group of François' langurs, which was representative in composition of other groups observed in Fusui (C. Huang, unpubl. data). The group size in 1999 was four (one male and three females) and five individuals were born during 2001 and 2003 (Cai 2004). There were no emigrations or immigrations during the study period.

Observation of feeding

During March 2003 - January 2004, we observed the langurs' feeding behaviour directly selecting strategic observation points from within 30-100 metres distance from the group. In the first eight consecutive days of each month, dietary data were collected via focal animal sampling and continuous recording (Altmann 1974, Martin & Bateson 1986) using a telescope for field observation (Nikon Fieldscope ED82, 25-75X Zoom, Japan). Two researchers were involved in the schedule: one observed langur feeding behaviour and the other one recorded among other things the feeding time, food species and food part in the tabular data sheet. On each study day, a mature langur individual was randomly selected as the focal animal and was observed during 06:30-18:30. On some occasions, we could not determine the focal animal's actions in trees and shrubs. Data collected during such periods were excluded from the analysed data set. The food items consumed by the langurs were recorded and the time that the focal animal spent feeding on each item was noted. Food items were described as leaves, fruits, flowers and buds. Feeding on a particular food source was considered to start when the animal put the food into its mouth and was considered to stop either when 20 seconds had passed without moving within the feeding site, when the focal animal left the feeding tree, or when the focal animal started eating another item. At that point, we designated this to be a completed feeding record. If the plant species being fed upon could not be identified simply by observation, a specimen was taken for identification in the laboratory. The plant taxonomy follows Flora of Guangxi (Guangxi Institute of Botany Academia Guangxiana 1986).

Vegetation characterisations

At the end of the field observation, we measured the relative frequency of the plant species and the forest characteristics in the habitat using the quadrat sampling method using 10 m × 10 m plots. Habitat variables, including tree, shrub and liana species, diameter at breast height (DBH; at 1.3 m above ground), and frequency of occurrence were recorded. Lianas were easily identified. Trees and shrubs were distinguished by their height and their main stem. Plants with a height of ≥ 5 m and an obvious stem were considered to be trees; otherwise, they were recorded as shrubs.

Herbs were not recorded as they were never observed to be used as a food resource by any of the focal langurs throughout the entire field observation. As previous observations have shown that the langurs feed on both trees and shrubs with a

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DBH of $>$ca 2 cm, and lianas of any DBH value, all trees and shrubs with a DBH of $\geq$2 cm and lianas with any DBH value were recorded within the quadrats. Only individual trees, shrubs and lianas with $>$50% of their base located inside the quadrat were counted.

The langur group utilised about 20% ($\sim$5.1 ha) of its habitat (Cai 2004). Following Struhsaker (1975), we sampled 3% of the group's home range ($\sim$16 quadrats). The hill could be classified into three main strata: hilltop, slope and lower slope. We thus stratified and randomly located five quadrats at the hilltop area, six on the slope and five at the lower slope areas. The proportion 5:6:5 was roughly related to the proportion of hilltop to slope and lower slope in the study area.

Data analysis

Sampling size among individuals was unequal, and repeated observations of the same individual were not independent from each other and should be treated differently to observations of other individuals. Following Post (1981), in each month, we calculated the mean diurnal feeding record and feeding time on species and food items from a sampled individual, and then we averaged the means across all individuals sampled. The total feeding time and feeding record was calculated by summing up the across-individual mean of each month. In the same way, the diurnal proportion of time spent feeding (species, life forms and food items) was calculated from a sampled animal in each month, and a mean across all individuals was then calculated. The cross-individual means of each month were averaged to calculate the annual proportion of time spent feeding.

Following Li et al. (2003), the plants species utilised in the langurs' diet were divided into three categories: staple species, seasonal species and rarely utilised species. Staple food is consumed in all months, seasonal species occurred in some seasons ($\geq$4 months) and rare species were species only eaten rarely ($\leq$3 months) by the langurs.

Because few trees occurring in the study area exceeded 30 cm DBH, and since much of the langurs' diet was composed of shrubs and lianas, the number of stems of a given plant species was used to quantify its abundance, rather than its basal area, in the home range. Using the equation from Krebs (1999) and Li et al. (2003), we calculated the selectivity index (S_i) for each of the species in the diet using the following equation:

$$S_i = F/V,$$

where F is the proportion of feeding records for a specific plant species over the total feeding records, V is the proportion of the number of stems of a specific plant species against the total number of individuals of all plant species in sample quadrats. The selectivity index expresses the degree to which langurs prefer or select a species relative to all possible species in the environment. A selection index value $>$1.0 indicates preference, whereas a value of $<$1.0 indicates avoidance (Krebs 1999).

We tested whether food selection is independent of the frequency of plant species abundance in the habitat applying the Spearman Rank Correlation (Li et al. 2003) by examining the correlation between feeding records (F) on species and relative plant abundance (V) in the quadrat.

Results

Food composition of François' langur

We spent 88 days observing animals (Table 1), during which we collected 2,037 feeding records. Feeding records ranged in duration from 10 seconds to 15 minutes. Annually, langurs spent 24.9% of the observation time feeding. In total, 40 plant species belonging to 33 families were recorded in the diet. The average number of monthly food species was 13.6 (SD = 3.29), ranging from 10 (during August) to 19 (during December; Fig. 2). Of these food species, four were identified as staple species, 22 as seasonal species and 14 were noted as rarely-consumed species (Table 2). Among the staple species, 23.8% were trees and 76.2% were shrubs.

Table 1. Total hours of focal-animal sample observations of four different individuals in a group of François' langurs in the county of Fusui, China, during March 2003 - January 2004.

Animal	March	April	May	June	July	August	September	October	November	December	January	Total
Male	15.5	15.5	14.5	16	16	15.5	15	16	13.5	14	13.5	165
Female 1	14	25.5	8.5	15.5	15.5	15.5	15	16	14.5	14.5	14.5	169
Female 2	15	14	16.5	16.5	16.5	16	28	16	14	15	14	181.5
Female 3	14.5	8	26.5	16	16	15.5	8	16	14.5	14.5	15	164.5

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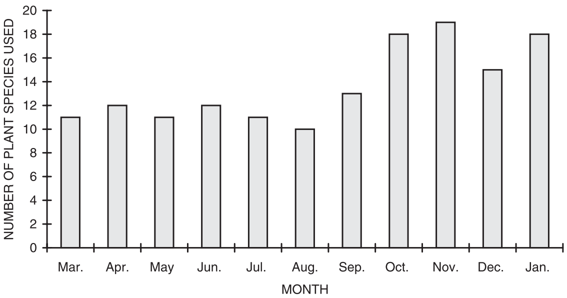

Figure 2. Numbers of plant species used by François' langur in the months March 2003 - January 2004.

Food resources included trees, lianas and shrubs. Shrubs made up the dominant food, accounting for 71.2% of feeding records, followed by lianas (18.2) and trees (10.5). No herb was observed to be consumed. As to the plant part used, the food items consisted of leaves of 36 species, flowers of four species, buds of seven species and fruits of 10 species (see Table 2). Leaves were the main food resource, on which langurs spent 86.9% of their mean annual feeding time, followed by fruits (9.3%), buds (3.1%) and flowers (0.7%). The proportion of time for

Table 2. Plant species used by the François' langurs and consumption parameters in the county of Fusui, China, during March 2003 - January 2004. F_i shows the food item of plant species as either L: leaf, B: buds, Fl: flower or Fr: fruit; F_t the total feeding time; F the proportion of specific feeding records for a specific plant species over the total feeding records; V the proportion of the number of stems of a specific plant species against the total number of individuals of all plant species in quadrats of a total area of ca 1.5 ha; and S_i the selectivity index.

Family	Species	Life form	Food type	Months used	F_i	F_t (min)	Feeding record	F	V	S_i
Anacardiaceae	*Pistacia weinmannifolia*	Shrub	Seasonal	5	L, Fr	245	51	2.48	1.98	1.25
Annonaceae	*Desmos chinensis*	Liana	Staple	11	L	740	151	7.40	3.52	2.10
Aslepiadaceae	*Mytiopteron extensum*	Liana	Rare	2	L, Fl	11	3	0.13	0.22	0.59
Bignoniaeceae	*Oroxylon indicum*	Shrub	Seasonal	4	L	21	4	0.22	5.29	0.04
Bombocaceae	*Bombax malabarica*	Tree	Seasonal	3	L	24	5	0.26	0.44	0.59
Caesalpiniaceae	*Bauhinia championii*	Liana	Rare	1	L	81	17	0.83	no	-
Capparidaceae	*Capparis vimines*	Shrub	Rare	1	L	21	5	0.24	0.44	0.55
Convolvulaceae	*Cuscuta chinensis*	Liana	Seasonal	4	B, Fl	64	13	0.65	no	-
Dillenicaceae	*Tetracera asiatica*	Liana	Rare	3	L	71	15	0.72	no	-
Elaeagnaceae	*Elaeagnus pungens*	Shrub	Rare	1	L	28	6	0.30	2.64	0.11
Euphorbiaceae	*Alchornea trewioides*	Shrub	Seasonal	4	L, Fr	61	13	0.64	5.07	0.13
Euphorbiaceae	*Fluggea virosa*	Shrub	Seasonal	5	L	44	9	0.46	0.66	0.70
Euphorbiaceae	*Phyllanthus embalia*	Shrub	Seasonal	7	L, Fr	897	198	9.74	0.66	14.76
Hyperiaceae	*Cratoxylon cochinchinese*	Shrub	Rare	1	L	11	3	0.13	2.86	0.05
Icacinceae	*Iodes ovalis*	Liana	Seasonal	4	L, B	21	5	0.26	no	-
Lauraceae	*Litsea glutinosa*	Shrub	Staple	11	L, B	1660	338	16.58	11.45	1.45
Linaceae	*Tirpitzia sinensis*	Shrub	Rare	1	L	21	4	0.21	7.49	0.03
Meliaceae	*Cipadessa cinerascens*	Shrub	Staple	11	L, B, Fr	1679	344	16.90	9.03	1.87
Menispermaceae	*Tinsospora capillipes*	Liana	Rare	2	Fr	75	16	0.76	0.88	0.86
Menispermaceae	*Cyclea racemosa*	Liana	Seasonal	3	L	17	4	0.20	0.88	0.23
Menispermaceae	*Stephania kwangsiensis*	Liana	Seasonal	5	L,	119	25	1.22	no	-
Mimosaceae	*Pterrobium punctatum*	Liana	Seasonal	4	L, Fl	81	17	0.82	2.20	0.37
Moraceae	*Broussonetia papyrifera*	Tree	Rare	1	L, Fr	21	4	0.21	0.44	0.48
Moraceae	*Cudrania cochnchinensis*	Shrub	Seasonal	7	L, B	184	39	1.91	1.98	0.96
Moraceae	*Ficus coninna*	Tree	Seasonal	8	L	427	90	4.44	no	-
Moraceae	*Ficus harmandii*	Tree	Seasonal	4	L	19	5	0.27	0.44	0.61
Myrtaceae	*Syzygium cumini*	Shrub	Seasonal	5	L	9	3	0.13	no	-
Oleaceae	*Ligustrum lucidum*	Shrub	Rare	1	L	74	16	0.78	no	-
Papilionaceae	*Paederia scandens*	Liana	Seasonal	6	L	315	67	3.31	0.66	5.02
Pittosporaceae	*Pittosporum glabratum*	Shrub	Staple	11	L, B	1958	399	19.62	2.64	7.43
Ranunculaceae	*Clematis chinensis*	Shrub	Seasonal	4	L, Fl	13	4	0.15	0.88	0.17
Rhamnaceae	*Berchemia floribunda*	Liana	Seasonal	4	L, B, Fr	121	25	1.24	no	-
Rhamnaceae	*Saferetia theezans*	Liana	Seasonal	4	Fr	27	6	0.28	1.10	0.25
Rutaceae	*Murraya paniculata*	Shrub	Rare	1	L	191	39	1.92	5.01	0.38
Sabiaceae	*Sabia japonica*	Liana	Seasonal	6	L	42	9	0.44	0.22	2.0
Solanaceae	*Solanum verbascifolium*	Shrub	Rare	1	Fr	16	3	0.16	no	-
Sterculiaceae	*Sterculia pexa*	Tree	Rare	2	L	78	16	0.79	0.22	3.59
Thymelaeaceae	*Wikstroemia indica*	Shrub	Rare	1	L, Fr	13	4	0.20	no	-
Tiliaceae	*Tilia tuan*	Tree	Rare	3	L	13	3	0.15	1.10	0.14
Ulmaceae	*Celtis tetrandra*	Tree	Seasonal	8	L	286	59	2.90	1.98	1.46

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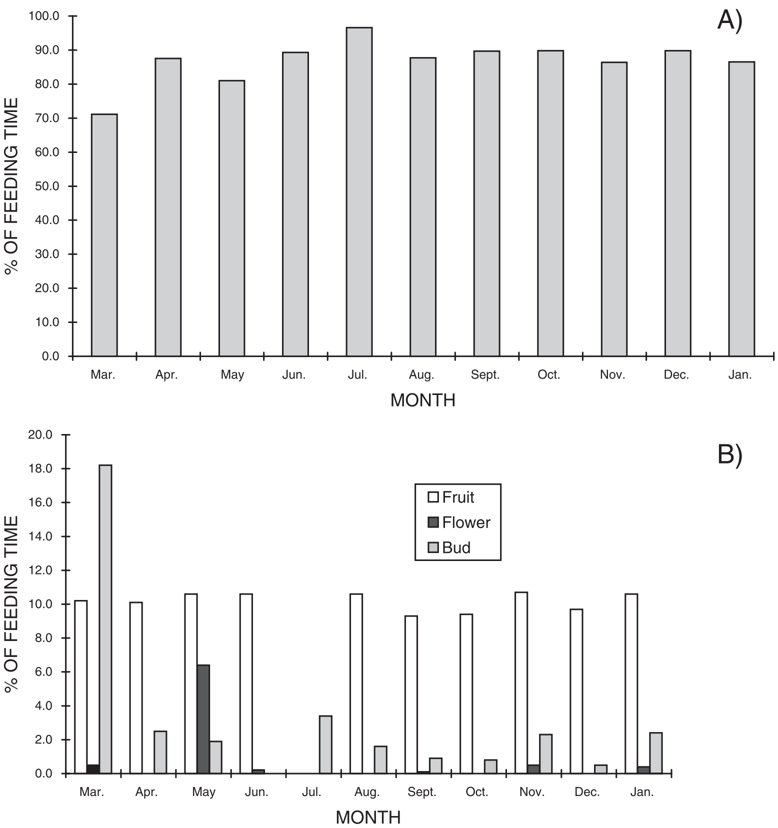

Figure 3. Proportion (in %) of langur feeding time allocated to foraging on leaves (A) and fruit, flowers and buds (B) in the months March 2003 - January 2004.

feeding on leaves ranged from 71.1% in March to 96.6% in July, and for feeding on fruits, it ranged from 10.7% in November to nil in July. Feeding on buds peaked in March, accounting for 18.2% of all feeding records in this month. Flowers were only consumed in six months of the year and only consisted of a small proportion of the food (Fig. 3). Whereas no obvious monthly variation in the proportion of feeding time was found on leaves and flowers (for leaves: $\chi^2 = 3.83$, df = 10, $P > 0.05$, and for flowers: $\chi^2 = 15.11$, df = 10, $P > 0.05$), a significant variation was found in the proportion of feeding time on fruits ($\chi^2 = 18.33$, df = 10, $P < 0.05$).

Species composition in home range

In total, 454 trees, shrubs (with a DBH of ≥ 2 cm) and lianas, belonging to 74 species, 67 genera and 45 families, were recorded in 16 quadrats of François' langur home range. Few trees with a DBH of > 30 cm were found, and small trees and shrubs were sparse. Of the plant species recorded, 35.7% were trees, 50.7% shrubs and 13.6% lianas. The 10 most abundant species are shown in Table 3. The home range was dominated by shrubs, lianas and saplings of trees. Trees with a DBH of > 15 cm were fast growing species such as Indian Trumpetflower *Oroxylon indicum* (belonging to the family Bignoniaceae), and common bomhax *Bombax malabarica* (belonging to the family Bombocaceae).

Food selection and frequency of plant species

François' langurs selectively used specific species as their main food resources, and in our study, only

Table 3. The 10 most abundant plant species in the langur home range as observed in January 2004, expressed in relative frequencies (RF) in the habitat.

Rank	Species	Family	RF
1	*Litsea glutinosa*	Lauraceae	11.5
2	*Cipadessa cinerascens*	Meliaceae	9
3	*Tirpitzia sinensis*	Linaceae	7.5
4	*Viburnum sempervirens*	Caprifoliaceae	6.6
5	*Oroxylon indicum*	Bignoniaceae	5.3
6	*Alchornea trewioides*	Euphorbiaceae	5.1
7	*Desmos chinensis*	Annonaceae	3.5
8	*Cratoxylon cochinchinese*	Hyperiaceae	2.9
9	*Elaeagnus pungens*	Elaeagnaceae	2.6
10	*Pittosporum tobira*	Pittosporaceae	2.6

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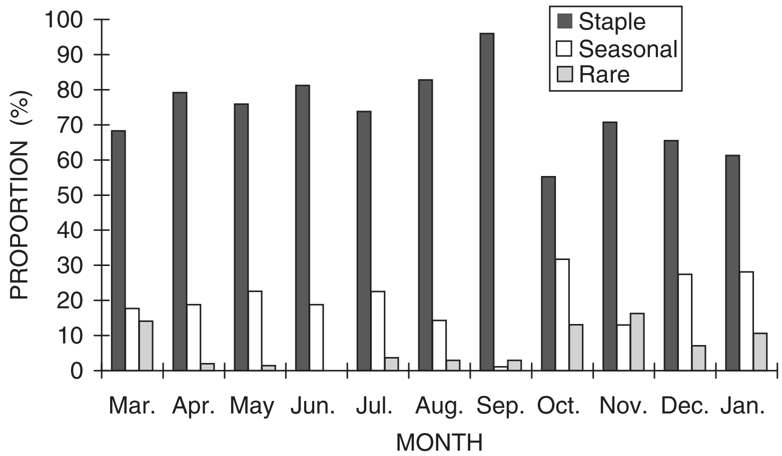

Figure 4. Proportion (in %) of langur feeding time spent on staple, seasonal and rare plant species in the months March 2003 - January 2004.

four species out of 40 were identified as staple. These were gluey litse *Litsea glutinosa*, seatung *Pittosporum glabratum*, *Cipadessa cinerascens* and Chinese desmos *Desmos chinensis*. Annually, the langurs spent 61.6% (ranging from 45.7% in December to 85.3% in September) of their feeding time on these four staple species (see Table 2 and Fig. 4), whilst only 38.4% of the feeding time was spent on the remaining 36 plant species that were either seasonally- or rarely-consumed food items. The feeding time spent on staple foods did not significantly vary among months ($\chi^2 = 17.22$, df = 10, $P > 0.05$). The cumulative frequency of these four staple species in the home range, as compared to all other species recorded, was only 26.6%, while the proportion of feeding time allocated to them, both annually and monthly, was disproportionately greater.

Annually, the langurs did not select food resources (tree, liana and shrubs) at random ($\chi^2 = 38.86$, df = 2, $P < 0.01$); they preferred shrubs to other plant forms. Of the food species, only 25% had S_i values of > 1 and another 47.5% had S_i values of < 1 (see Table 2). The percentage of feeding records (F) was not significantly correlated with plant source abundance in the home range (V; $r_s = 0.32$, $P > 0.05$, N = 29).

Discussion

Habitat fragmentation can have profound effects on the number of food species utilised by animals. Species richness is positively correlated to the size of habitat fragments. Habitat fragmentation is thus reflected by the smaller number of plant species utilised by primates (Bicca-Marques 2003). As a result of isolation and selective firewood selection, our study habitat has a simpler vegetation structure dominated by short vegetation and lianas, than what has been documented in neotropical habitats (Offerman et al. 1995, Chiarello 2003). These disturbed and fragmented habitats differed considerably from the habitats of langurs in less disturbed conditions which are characterised by more trees and taller shrubs (Li 1993, 2000, Xue 2000). The numbers of plant species used by our focal group were considerably smaller than that of other groups from less fragmented or less disturbed sites. Langurs in our study also fed primarily on leaves and little on fruits. In contrast, in continuous habitats, langurs have been observed to be less folivorous (Table 4).

François' langurs selectively used plant species as a food resource, though in fragments, they used fewer food species. The correlation between the per-

Table 4. Size of area (in ha), type of habitat, number of plant food species used and the amount of time (in %) spent on the different plant parts used by François' langur at three sites in the Guangxi Province (A) and two in the Guizhou Province (B), China. - indicates that detailed data are unavailable.

Study site	Area (ha)	Habitat	Species used	Time spent on plant parts (in %)							Source
				Leaves	Fruits	Flowers	Petiole	Buds	Seeds	others	
Fusui[A]	25.7	fragment	40	86.9	9.3	0.63	0	3.1	0	0	Our study
Longgang[A]	5424.7	continuous	90	52.8	17.2	7.5	4.1	4.1	14.2	0.1	Zhou et al. 2006
Longgang[A]	5424.7	continuous	117	57.6	15.9	0	10.1	0	15.9	1.1	Luo 2005
Mayanghe[B]	31114	continuous	103	-	-	-	-	-	-	-	Luo et al. 2000
Dashahe[B]	6666.7	continuous	136	-	-	-	-	-	-	-	Lan 1994

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centage of feeding records and the species abundance in the home range was insignificant, suggesting that the food plants were being selectively used by the langurs independent of their relative abundance. The nature of the food selectivity of langurs in the fragmented habitat is identical to the food selectivity shown in other leaf-eating colobine species in continuous habitats (Onderdonk & Chapman 2000, Umapathy & Kumar 2000, Li et al. 2003, Zhou et al. 2006).

Langurs spent the majority of their feeding time on only a small proportion of food resources (four staple species), only occasionally supplementing their diet with various other plant species (see Fig. 4). The selectivity for these staple species was consistent from month to month. Onderdonk & Chapman (2000) pointed out that the black-and-white colobus has a relatively monotonous diet. If the right food species were not available, they might not be expected to succeed in habitats with a limited number of food species. However, if they can be monotonous on what is available, then their dietary strategy may be beneficial in a species-poor forest fragment. This may be the case for our focal group of François' langurs.

The highly selective diet of our study population may be an adaptive strategy in response to fragmentation. François' langurs spent much of their time feeding on shrubs (71.2%) and lianas (18.2; our study) and the monthly time spent on these two growth forms accounted for the majority of feeding time (C. Huang, unpubl. data). Forest fragments have a much higher ratio of edge to area than do continuous forests. Shrubs and lianas are abundant along forest edges, and the phenology of these species is less seasonal than trees, especially in terms of the production of new leaves (Putz & Windsor 1987, Chiarello 1994, 2003). For colobines, there is evidence that the ability to live on edges may be related to a dietary preference for secondary growth (Onderdonk & Chapman 2000, Wong et al. 2006).

Although apparently strictly herbivorous (Luo 2005, Zhou et al. 2006, Lan 1994, our study), François' langurs showed great dietary flexibility. They used different amounts of plant species and spent different times feeding on different food items across sites (see Table 4). Of all food species, nettletree *Celtis sinensis* is the only one commonly consumed by François' langurs at different sites. This may have enabled the species to persist in fragments. Likewise, it provides a higher potential of success regarding possible reintroduction or translocation of langurs into unoccupied habitat fragments with differing food resources. This instills some hope for survival and recovery of this threatened species, provided that further habitat degradation and fragmentation can be restricted and remaining habitat areas for the species can be protected.

It has been argued that success in coping with habitat fragmentation in howler monkeys *Alouatta* spp. is determined by their ability to fulfill their nutritional requirements by encompassing a greater quantity of leaves in their diet (Crockett 1998, Estrada et al. 1999, Marsh 2003), whereas Onderdonk & Chapman (2000) argued that the degree of frugivory does not predict the ability of black-and-white colobus and red colobus *Piliocolobus kirkii* to live in isolated patches. Compared with their counterparts in continuous habitat (see Table 4), our focal group utilised fewer food species, spending the majority of their time feeding on staple foods, or shrubs and lianas. This can be seen to be an adaptive foraging strategy. However, the dietary data and these inter- and intra-specific comparisons are based on only a small sample time and one group of François' langurs from one fragment. We must be cautious about making generalisations about François' langur responses to fragmentation from our study, as primate responses to a changed habitat may be site- and disturbance-specific (Fimbel 1994, Onderdonk & Chapman 2000). With more studies of dietary pattern across more groups in more fragmented habitats, we may be able to determine the generality of these patterns.

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References

Altmann, J. 1974: Observational study of behavior: Sampling methods. - Behavior 49: 227-267.

Bicca-Marques, J.C. 2003: How do howler monkeys cope with habitat fragmentation? - In: Marsh, L.K. (Ed.); Primates in fragments-ecology and conservation. Kluwer Academic/Plenum Publisher, New York, pp. 283-304.

Cai, X.W. 2004: The research on feeding biology and nutritional analysis of *Trachypithecus francoisi*. - M.Ph

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thesis, Guangxi Normal University, Guilin, pp. 32-34. (In Chinese).
Canh, L.X. 1996: Endangered primate species in Vietnam. - Primate Conservation 17: 117-126.
Chiarello, A.G. 1994: Diet of the brown howler monkey *Alouatta fusca* in a semi-deciduous forest fragment of southeastern Brazil. - Primates 35: 25-34.
Chiarello, A.G. 2003: Primates of the Brazilian Atlantic Forest: the influence of forest fragmentation on survival. - In: Marsh, L.K. (Ed.); Primates in fragments-ecology and conservation. Kluwer Academic/Plenum Publisher, New York, pp. 99-122.
Crockett, C.M. 1998: Conservation biology of the genus *Alouatta*. - International Journal of Primatology 19: 549-578.
Estrada, A. & Coates-Estrada, R. 1996: Tropical rain forest fragmentation and wild populations of primates at Los Tuxtlas, Mexico. - International Journal of Primatology 17: 759-783.
Estrada, A., Juan-Solano, S., Martinez, T.O. & Coates-Estrada, R. 1999: Feeding and general activity patterns of a howler monkey (*Alouatta palliata*) troop living in a forest fragment at Los Tuxtlas, Mexico. - American Journal of Primatology 48: 167-183.
Fimbel, C. 1994: Ecological correlates of species success in modified habitats may be disturbance- and site-specific: the primates of Tiwai Island. - Conservation Biology 8(1): 106-113.
Guangxi Institute of Botany Academia Guangxiana 1986: Flora of Guangxi. - Guangxi Science and Technology Publishing House, Nanning. (In Chinese).
Hu, G., Dong, X., Wei, Y., Zhu, Y. & Du, X.H. 2004: Evidence for a decline of François' langur *Trachypithecus francoisi* in Fusui Nature Reserve, south-west Guangxi, China. - Oryx 38(1): 1-7.
IUCN 2004: 2004 IUCN Red List of Threatened Species. - Available at: http//www.redlist.org (Last accessed on 2 November 2006).
Krebs, C.J. 1999: Ecological Methodology. - Addison-Wesley, England, pp. 478-482.
Lan, K.M. 1994: The report on the nature resource of Dashahe Reserve. - Guizhou Nationality Press, Guiyang, pp. 59-68. (In Chinese).
Li, Y.B., Huang, C.M., Ding, P., Tang, Z. & Wood, C. 2007: Dramatic decline of François' langur (*Trachypithecus francoisi*) in Guangxi Province, China. - Oryx 41(1): 38-43.
Li, Z.Y. 1993: The research on ecology and behavior of leaf monkeys in China.- In: Ye, Z.Z. (Ed.); Biology of Leaf Monkey. Yunnan Science and Technology Press, Kunming, pp. 27-51. (In Chinese).
Li, Z.Y. 2000: The socioecology of white-headed langur *Presbytis leucocephalus*, and its implication for their conservation. - PhD thesis, University of Edinburgh, Scotland, pp. 48-52.
Li, Z.Y., Wei, Y. & Rogers, E. 2003: Food choice of White-headed Langurs in Fusui, China. - International Journal of Primatology 24(6): 1189-1205.
Limestone Research Team of Guangxi Academy Institute 1994: Research on feasibility of ecological restoration of Guangxi limestone region. - Guangxi Science and Technology Press, Nanning, pp. 389-312. (In Chinese).
Liu, W.F. & Wei, Z.Y. 1995: Present status and protection of primate resources in Guangxi, China. - In: Xia, W.P. & Zhang, R.Z. (Eds.); Primate research and conservation. China Forestry Publish House, Beijing, pp. 123-132. (In Chinese).
Lovejoy, T.E., Bierregaard, R.O., Jr., Rylands, A.B., Malcolm, J.R., Quintela, C.E., Harper, L.H., Brown, K.S., Powell, A.H., Powell, G.V.N., Schubart, H.O.R. & Hays, M.B. 1986: Edge and other effects of isolation on Amazon forest fragments. - In: Soulé, M.E.. (Ed.); Conservation Biology: The Science of Scarcity and Diversity. Sinauer Associates, Massachusetts, USA, pp. 257-285.
Luo, B. 2005: The research on feeding ecology and nutrition analysis of *T. francoisi* in Longgang Reserve. - M.Ph thesis, Guangxi Normal University, Guilin, pp. 16-20. (In Chinese).
Luo, Y., Chen, Z.R. & Wang, S.X. 2000: Observation on the food habit of *Presbytis francoisi* in Mayanghe Region, Guizhou Province. - Chinese Journal of Zoology 35(3): 44-49. (In Chinese).
Marsh, L.K. 2003: The nature of fragmentation. - In: Marsh, L.K. (Ed.): Primates in fragments-ecology and conservation. Kluwer Academic/Plenum Publisher, New York, pp. 1-10.
Martin, P. & Bateson, P. 1986: Measuring Behavior: an Introductory Guide. 2nd Edition. - Cambridge University Press, Cambridge, pp. 84-100.
Nadler, T., Momberg, F., Dang, N.X. & Lormee, N. 2003: Vietnam Primate Conservation Status Review 2002, Part 2: Leaf monkeys. - Fauna & Flora International-Vietnam Program and Frankfurt Zoological Society, Hanoi, pp. 35-40.
Noss, R.F. & Csuti, B. 1994: Habitat fragmentation. - In: Meffe, G.K. & Carroll, C.R. (Eds.); Principles of Conservation Biology Sinauer Associates, Massachusetts, USA, pp. 237-264.
Offerman, H.L., Dale, V.N., Pearson, S.M., Bierregaard, O., Jr. & O'Neill, R.V. 1995: Effects of forest fragmentation on neotropical fauna: current research and data availability. - Environmental Review 3: 190-211.
Onderdonk, D.A. & Chapman, C.A. 2000: Coping with forest fragmentation: the primates of Kibale National Park, Uganda. - International Journal of Primatology 21(4): 587-611.
Post, D.G. 1981: Activity patterns of yellow baboons (*Papio cynocephalus*) in the Amboseli National Park, Kenya. - Animal Behavior 29: 357-374.

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Putz, F.E. & Windsor, D.M. 1987: Lianas phenoloy on Barro Colordo Island. - Biotropica 19(4): 334-341.
Umapathy, G. & Kumar, A. 2000: The occurrence of arboreal mammals in the rain forest fragments in the Anamalai Hills, South India. - Biological Conservation 92: 311-319.
Wang, Y.X., Jiang, X.L. & Feng, Q. 1999: Taconomy, status and conservation of leaf monkey in China. - Zoological Research 20(4): 306-315.
Wong, S.N.P., Saj, T.L. & Sicotte, P. 2006: Comparison of habitat quality and diet of *Colobus vellerosus* in forest fragments in Ghana. - Primates 47(4): 365-373.
Wong, S.N.P. & Sicotte, P. 2007: Activity budget and ranging patterns of *Colobus vellerosus* in forest fragments in central Ghana. - Folia Primatologica 78: 245-254.
Wu, M.C. 1983: On the distribution and population estimation of primates in Guangxi Province. - Acta Theriologica Sinica 3: 16. (In Chinese).
Wu, M.C., Wei, Z.Y. & He, N.L. 1987: Distribution and ecology of black leaf monkey (*T. f. françoisi*) in Guangxi Province. - Chinese Wildlife 4: 12-13.
Xue, Y.G. 2000: Guangxi Tropical Flora. - Guangxi Normal University Press, Guilin, pp. 45-48. (In Chinese).
Zhang, R.Z., Quan, G.Q., Zhao, T.G. & Southwick, C.H. 1992: Distribution of primates (except *Macaca*) in China. - Acta Theriologica Sinica 12(2): 81-95.
Zhou, Q.H., Wei, F.W., Huang, C.M. & Li, M. 2006: Diet and Feeding Behavior of the François' Langur (*Trachypithecus francoisi*) in Nonggang Nature Reserve, China. - International Journal of Primatology 27(5): 1441-1460.

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