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Feeding behaviour and diet of grey-shanked douc langurs (*Pygathrix cinerea*) in Kon Ka Kinh National Park, Vietnam

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Key words: Grey-shanked douc langur, *Pygathrix cinerea*, feeding behaviour, diet

Summary

The data on feeding behaviour of grey-shanked douc langurs were collected from August 2007 to July 2008 in Kon Ka Kinh National Park, Gia Lai Province, Vietnam. In total, 880 feeding records, among 7,390 observations were made within 480 hours of direct observation of the study groups and 166 plant species of 40 plant families were identified as diet of the grey-shanked douc langurs. The feeding list comprises 115 species identified based on food remains and 51 species identified based on direct observation. Top 10 plant families comprise 59% of all species in the feeding list. Moraceae, Fagaceae and Myrtaceae are the top 3 tree families with the highest number of food plant species. Myrtaceae, Sapindaceae and Moraceae are the top 3 most eaten tree families. The top 10 most eaten families highly overlap with the top 10 most abundant families in the study site. *Pometia pinnata* was the most selected plant species in the diet with the selection ratio value 59.4 based on stem density and *Syzygium petelotii* was the most selected species with selection ratio value 129.2 based on the total basal area. The grey-shanked douc langurs fed 49.5% on young leaves, 21.9% on ripe fruits 19.1% on unripe fruits and only 9.3% on mature leaves. The proportion of food items eaten by the monkeys varied significantly over the months. The highest proportion of young leaves were eaten in February and the highest proportion of fruit in October. The monthly consumption of young leaves was significantly correlated to the abundance of the young leaves, but the monthly consumption of fruits was not significantly correlated to the abundance of fruits. The consumption of food items changed significantly between the wet and the dry season. The doucs ate mostly young leaves in the dry season (82%) when it was abundant and switched to fruits (~70%) in the wet season when young leaves became rare and fruits were abundant. Mature leaves were consumed more often in the wet season. Among the douc langur species, the grey-shanked doucs eat more leaves (58.8%) than black-shanked doucs ($\bar{x}$= 47.2%) but less than red-shanked doucs ($\bar{x}$= 72%). The grey-shanked doucs eat fruits and seeds more than red-shanked doucs ($\bar{x}$= 18.4%) and the same proportion as black-shanked doucs ($\bar{x}$= 40%). The doucs have a flexible dietary and feed on a high proportion of fruits and seeds. Among the odd-nosed monkey group (douc langurs, snub-nosed monkeys and proboscis monkeys) the diet composition and proportion of plant parts of the douc langurs is rather similar to that of the proboscis monkeys than to the snub-nosed monkeys. The douc langurs and proboscis monkeys feed mostly on leaves and fruits while snub-nosed monkeys consume a substantial a high amount of lichen.

Tập tính ăn và thức ăn của loài chà vá chân Xám (*Pygathrix cinerea*) ở Vườn Quốc gia Kon Ka Kinh, Việt Nam

Tóm tắt

Số liệu về tập tính ăn của loài chà vá chân xám được thu thập từ tháng 8 năm 2007 đến tháng 7 năm 2008 tại Vườn Quốc gia Kon Ka Kinh, Tỉnh Gia Lai, Việt Nam. Tổng số có 880 dữ liệu tập tính ăn trong 7,390 quan sát từ 480 giờ theo dõi trực tiếp các bầy chà vá chân xám trong điều kiện tự nhiên. Nghiên cứu đã xác định được 166 loài thực vật thuộc 40 họ là thức ăn của loài chà vá chân xám. Danh sách bao gồm 115 loài được ghi nhận từ mẫu thức ăn còn thừa rơi vãi trên đất, và 51 loài quan sát trực tiếp. Có 10

họ thực vật chiếm đến 59% tổng số loài là thức ăn của chà vá chân xám. Các họ Moraceae, Fagaceae, và Myrtaceae là 3 họ có số loài là thức ăn nhiều nhất. Trong khi đó, các họ thực vật Myrtaceae, Sapindaceae, và Moraceae là 3 họ có số cây được ăn nhiều nhất. Top 10 họ thực vật được ăn nhiều nhất có sự giao thoa rất lớn với top 10 họ thực vật phổ biến nhất trong khu vực nghiên cứu. Loài *Pometia pinnata* được chọn nhiều nhất trong số các loài thực vật là thức ăn với tỷ lệ chọn là 59,4 căn cứ trên mức độ phong phú của số cây. Loài *Syzygium petelotii* được chọn nhiều nhất với tỷ lệ chọn là 129,2 căn cứ trên tổng diện tích ngang của cây. Chà vá chân xám ăn 49,5% lá non, 21,9% quả chín, 19,1% quả xanh, và chỉ có 9,3% là già. Thành phần thức ăn của chà vá chân xám thay đổi khác biệt giữa các tháng. Lá non được ăn nhiều nhất vào tháng 1 và quả (chín và xanh) được ăn nhiều nhất vào tháng 10. Mức tiêu thụ lá non có mối quan hệ thống kê chặt với mức độ phong phú của lá non hàng tháng, tuy nhiên không có mối quan hệ rõ ràng giữa mức tiêu thụ quả và sự phong phú của quả theo tháng. Mức độ tiêu thụ các loại thức ăn khác nhau thay đổi một cách có ý nghĩa thống kê giữa mùa mưa và mùa khô. Chà vá chân xám ăn chủ yếu là lá non vào mùa khô (82%) khi lá non phong phú, và đổi sang ăn quả (70%) vào mùa mưa khi lá non hiếm và quả trở nên phong phú. Đồng thời, lượng lá già cũng được ăn đáng kể trong mùa mưa. Trong số 3 loài chà vá, chà vá chân xám ăn nhiều lá (58,8%) hơn chà vá chân đen ($\bar{x}$= 47%), nhưng ít hơn chà vá chân nâu ($\bar{x}$= 72%). Chà vá chân xám ăn nhiều quả và hạt hơn chà vá chân nâu ($\bar{x}$= 18.4%) và tương đương với loài chà vá chân đen ($\bar{x}$= 40%). Chà vá chân xám có sự thay đổi linh hoạt thành phần các loại thức ăn, và ăn nhiều quả và hạt. So sánh trong nhóm khỉ mũi lạ (odd-nosed monkey) gồm có voọc chà vá, voọc mũi hếch, và khỉ proboscis cho thấy, thành phần loài thức ăn và loại thức ăn của voọc chà vá có nhiều điểm tương đồng với khỉ proboscis. Cả voọc chà vá và khỉ proboscis đều ăn chủ yếu lá và quả, trong khi đó voọc mũi hếch ăn một lượng đáng kể địa y.

Introduction

As a colobine monkey, the grey-shanked douc langurs (*Pygathrix cinerea*) shares the common characteristic of their unique digesting system among primates. Digesting process of the colobine monkeys is quite similar to that of ruminants (Bauchop & Martucci 1968; Chivers 1994; Kay & Davies 1994). The stomach of colobine monkeys is characterised by enlarged and sacculated chambers containing an array of bacteria that ferment the ingested food to produce volatile fatty acids absorbed by the monkeys (Kay & Davies 1994). The digesting structure is an adaption to response to the chemical problems of digesting leaves, as well as to neutralising the affects of digestion inhibitors and toxins (Chivers 1994; Caton 1998).

The typical diet of the Asian colobines consists of young leaves, unripe fruits and seeds, which are preferred over mature leaves. Ripe fruits are usually avoided (Yeager & Kool 2000). Since 1970's diet of the colobines have been studied comprehensively in Africa (Oates 1977; Struhsaker & Oates 1979; Dasilva 1994; Fashing 2001; Chapman & Chapman 2002) and Asia (Bennett 1983; Davies 1984; Kirkpatrick 1998; Yeager & Kool 2000; Matsuda et al. 2009). The colobines are determined as folivorous monkeys but in some studies their diet contains also large proportion of fruits and seeds. For example, *Presbytis rubicunda* eat over 80% seeds in some months (Davies 1991).

Since 1980's feeding behaviour and diets of the odd-nosed monkey group including *Rhinopithecus*, *Pygathrix* and *Nasalis* were studied in Southeast Asia and China (Yeager 1989; Boonratana 1993; Kirkpatrick 1998; Lippold 1998; Kirkpatrick et al. 2001; Li 2006; Guo et al. 2007; Grüter 2009; Matsuda et al. 2009). However, field research on *Pygathrix* genus is still limited due to the difficulty of access for researchers to habitat countries; Vietnam, Laos and Cambodia. However, early knowledge on feeding ecology on *Pygathrix* was acquired since the Vietnam War. Kavanagh (1972) and Gotchfield (1974) reported rare food-sharing behaviour among individuals of red-shanked douc langurs (*P. nemaeus*) in captivity and in the wild. Pham Nhat (1993) conducted a study of food components in stomachs of red-shanked douc langurs and provided a list of 50 food tree species. The main food items eaten by the red-shanked douc langurs were leaves, buds, fruits, seeds and flowers. However, the proportion of food items was not clear. Lippold (1998) proposed that food of red-shanked douc langurs contains mostly leaves and a little flowers and seeds. Hoang Minh Duc (2007) conducted a study on the ecology of black-shanked douc langurs (*P. nigripes*) in the national parks Nui Chua and Binh Chau Phuoc Buu, Vietnam and reported that the langurs eat at least 152 plant species of 37 plant families.

Up to date, information about feeding behaviour and ecology of the grey-shanked douc langur is still limited. This study should add more information on feeding behaviour and diet.

Material and Methods

Locality and study period

The data on feeding behaviour were collected from August 2007 to July 2008 in Kon Ka Kinh National Park, Gia Lai Province, Vietnam (Fig. 1)

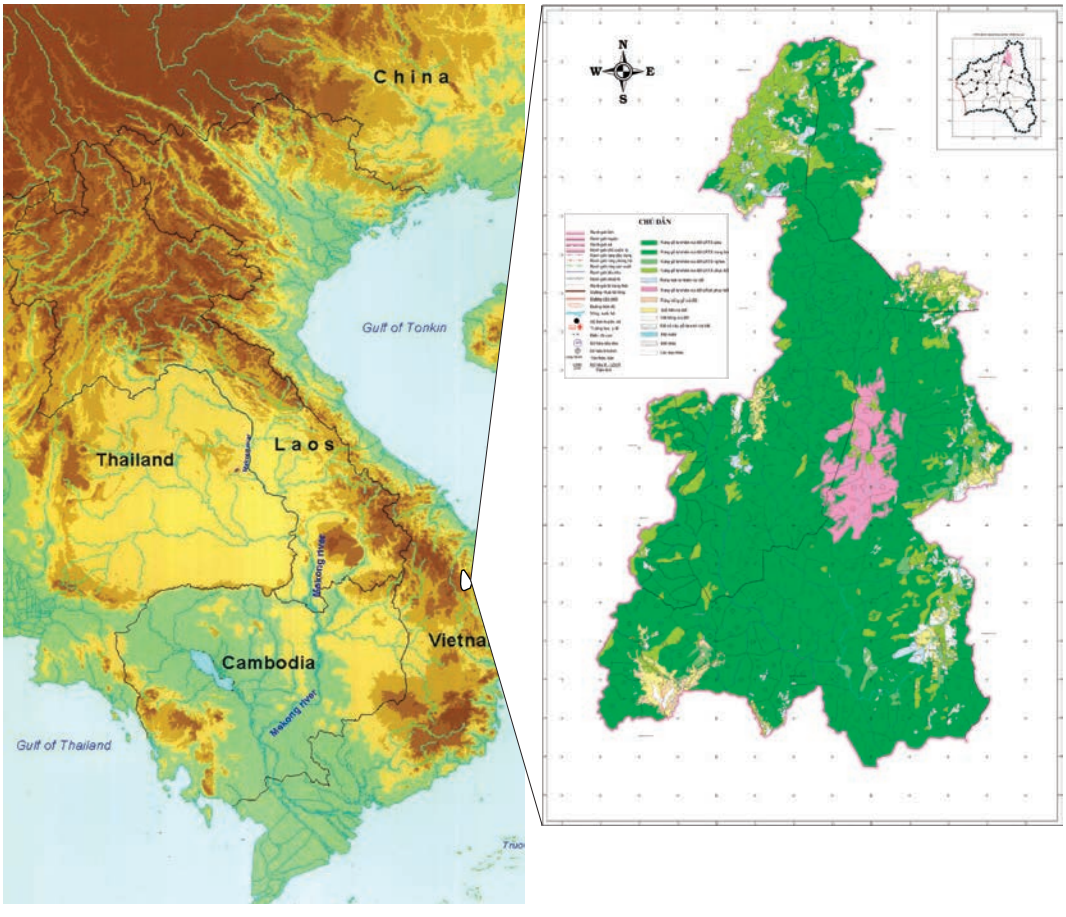

Fig.1. Kon Ka Kinh National Park in Vietnam.

Activity recording

In total 880 feeding records among 7,390 observations were made within 480 hours of direct observation of the study groups. Data were collected using instantaneous scan-sampling method (Altmann 1974; Martin & Bateson 1993) with 5-minute intervals. The activity recorded for each individual was the first activity that lasted for more than 3 seconds once the individual was sighted. This requirement would reduced eye-catching behaviour such as playing behaviour, from being overrepresented in the data set (Bennett 1983; Fashing 2001). The cut-off was set at 5 individuals - adults, juveniles and infants - in each scan. Since the 5 individuals were the maximum number of individuals to scan effectively without counting the same individual twice during a scan (Fashing 2001). However, many occasions there were less than 5 individuals in one scan due to limited visibility.

Feeding was defined when a group member was inspecting food, bringing it to the mouth, chewing and swallowing it. When an individual was seen eating plant items (leaves, fruit seeds, flowers and others), the feeding score was recorded for that item. If the monkey was feeding at the time of a scan, the tree where the monkey fed on was tagged with a number and later a herbarium sample collected. The leaves were classified as young leaves, mature leaves, and fruits were classified as ripe and unripe.

Collection of food items

Species of plants eaten by the langurs were collected using two methods:

1. Direct observation on each scan when the langurs feed, feeding trees were tagged with a number and herbarium specimens later on collected;
2. Collection of food remains on the ground after the monkey left the site.

The food remains that were less than two-days old were also collected. In this case, the samples were examined carefully to ensure that the remains belong to the langurs and not to another species. The obvious sign of the food remains from douc langurs was the shape of the bite mark on the leaves (Fig. 2). When collecting fruits the indentation from the teeth was carefully examined and compared with the indentation of the bite shapes on the leaves. Only young leaves and mature leaves were counted (leaf buds were included in the leaf category), seeds were lumped into the fruit category. The method used in this study followed suggestions made on recording data on food item remains for studies on primate diet by McGrew et al. (1988).

Fig.2. Signs used to determine the food remains (leaves and fruits) of grey-shanked douc langurs. Photo: Ha Thang Long.

Data analysis

Kavanagh (1978) proposed that bias towards those scans during which many subjects were visible would be reduced by weighting each scan equally. Weighting data was done by dividing each observation by the total number of observations in a scan (Kool 1989). For example, if there are 5 observations in a scan, each observation will be scored as 1/5. In this study, un-weighted data were used to analyse the proportion of time spent in feeding. The reason was that the number of individuals in each scan was quite consistent and under 5 individuals.

Selection ratios

The selection for food species in the diets of the study group in terms of ratios was calculated by measuring dietary selectivity. A food species that was selected is eaten more frequently than expected based on its proportional representation in the forest. When the ratio is greater than one, the monkeys ate a given species to a greater extent than would be expected if they were feeding at random. So, they were being selective in what they ate (McKey et al. 1981; Kool 1993; Fashing 2001). Two formulas were used to calculate selection ratios, one based on the stem density of tree species

and the other based on the basal area (BA).

$$\text{Selection ratios 1} = \frac{\text{\% of annual feeding time spent feedimg on species (i)}}{\text{\% of stem density contributed by species (i)}}$$

$$\text{Selection ratios 2} = \frac{\text{\% of annual feeding time spent feeding on species (i)}}{\text{\% of total basal area contributed by species (i)}}$$

Productivity Index

Data were collected on relative abundance of young leaves (YL), flowers (FL) and fruits (FR), as they were recognised as main foods of the douc langurs in previous studies. The relative abundance of plant parts was estimated, using a visual-count method (Chapman et al. 1992). At first, one branch was sub-sampled by counting for new leaves, flowers and fruits on the branch then extrapolated for the whole crown of the tree. The relative abundance of plant parts at 4 levels was scored as follows: 1= in 0-25%; 2= in 26-50%; 3= in 51-75% 4= in 76-100% of the whole tree crown. In total, 327 trees with dbh ≥ 30 cm were monitored. The monthly Productivity Index of fruits, flowers and young leaves was calculated:

$$\text{Productivity Index (fruits, flowers, young leaves)} (month_i) = \frac{\sum_{k=1}^{4} P[k]_i * k}{\sum_{k=1}^{4} P[k]_i}$$

k = score levels of young leaves, fruits and flowers from 1 to 4

P[k]I = total trees counted in month *i*, at different score level

Productivity Index with a value range between 1 and 2

Results

Feeding pattern

The langurs started to eat immediately as soon as they moved out from the sleeping tree between 5:00 and 6:00 am. The langurs fed all the day, but there are two peaks of feeding time, one in the early morning at 6:00 am and another in the afternoon at 4:00 pm. The lowest feeding time was around 9:00 am. During this time the langurs spent the longest time for resting.

There is a difference in the time budget for feeding between wet and dry season. In the wet season (May to November) the langurs fed more extensively in the early morning and late afternoon and in the dry season (from December to April) they fed more frequently during different hours of the day. In the course of a year, the langurs spent the highest proportion of feeding time in January and lowest proportion in November. The nutrition value of plant parts the langurs eat and the availability of them during different time of the year might lead to such patterns.

Food items annually

Four main food items eaten by the monkeys were: young leaves, mature leaves, unripe fruits and ripe fruits during the 12 months of study. Annually, the langurs fed mainly on young leaves which accounted for about 49.5% of food items. Ripe fruits and unripe fruits were also eaten in high proportions, 21.9% for ripe fruits and 19.1% for unripe fruits, respectively. Mature leaves were eaten but in low proportion with only 9.3% (Fig. 3).

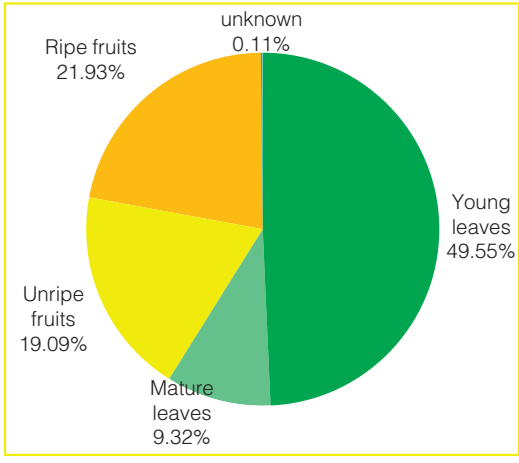

Fig.3. Anual proportion of food items fed by the grey-shanked douc langurs.

Food items monthly

The monthly proportion of food items varied significantly over the months (X^2=912.5, df=33, p<0.0001). The langurs fed more on young leaves in the dry months from December to April with a peak in February, and fed on more fruits in the wet months from May to November with a peak in October (Fig. 4; Table 1). For example, in February 2008 the langurs fed the greatest proportion of young leaves (96.4%), while they fed far less on unripe fruits and mature leaves for 2.7% and 0.9% respectively. In October 2007, the langurs ate mainly fruits (96.2%) and only 3.8% young leaves.

Fig.4. Monthly proportion of food items fed by the grey-shanked douc langurs.

Table 1. Monthly proportion of food items fed by the grey-shanked douc langurs.

	Young leaves	Mature leaves	Unripe fruits	Ripe fruits	Unknown
Aug-07	3.8	0.0	76.9	19.2	0.0
Sep-07	8.3	0.0	8.3	83.3	0.0
Oct-07	3.8	0.0	69.8	26.4	0.0
Nov-07	48.9	8.5	31.9	10.6	0.0
Dec-07	35.6	5.5	12.3	46.6	0.0
Jan-08	86.2	9.2	3.4	0.0	1.1
Feb-08	96.4	0.9	2.7	0.0	0.0
Mar-08	95.5	0.9	0.0	3.6	0.0
Apr-08	80.0	20.0	0.0	0.0	0.0
May-08	30.9	0.0	48.1	21.0	0.0
Jun-08	18.2	7.3	19.1	55.5	0.0
Jul-08	7.8	50.0	0.0	42.2	0.0

The monthly changing in consumption of food items is related to the abundance of the food items. The correlation between Young Leaves Productivity Index and consumption of young leaves was positive significant (r_s= 0.77, p=0.003). An example being that the langurs fed on the greatest proportion of young leaves in February 2008 when the Productivity Index of young leaves was highest (1.9). It means they ate young leaves when it was most abundant. Similarly, the monkeys fed the greatest proportion on fruits in October 2007 when the Productivity Index of fruits was highest (1.28). Although the correlation between Fruit Productivity Index and consumption of fruits was not significant (r_s= 0.52, p=0.07).

Seasonal changes in food items

The consumption of food items changed significantly between the wet and the dry season (X^2= 371.4, df=3, p<0.0001). In the dry season, the langurs fed mostly on young leaves (82%) and far less on mature leaves (5.7%), ripe fruits (8.7%) and unripe fruits (3.4%). In the wet season, the langurs fed mostly on fruits ~70%, their diet comprising of 34.8% ripe fruits and 34.4% unripe fruits. Young leaves were also eaten but in a low proportion of 17.9%. Mature leaves were eaten least among the food items with only 12.8% (Fig. 5).

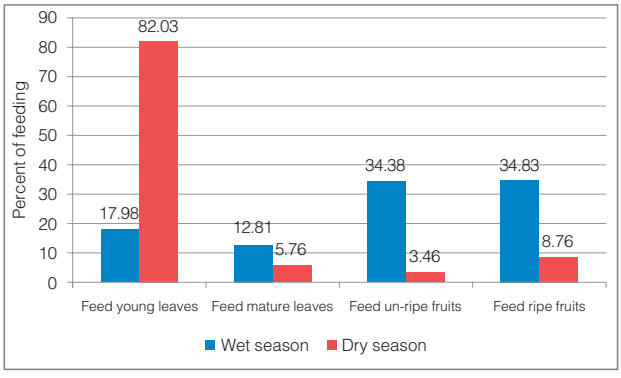

Fig.5. Seasonal proportion of food items fed by the grey-shanked douc langurs.

In conclusion, although mature leaves are available year-round they were rarely eaten. Young leaves were more available in the dry season and the langurs fed extensively on these food items (Fig. 6). Fruits, including seeds were also eaten extensively in the wet season when they were more abundant (Fig. 7).

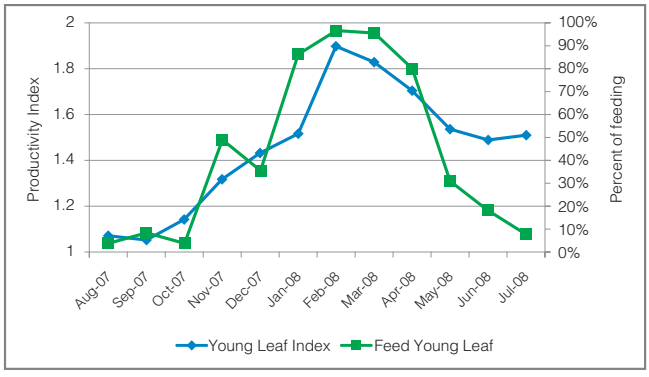

Fig.6. Correlation between 'Young Leaf Index' and monthly fed young leaves (r_s = 0.77).

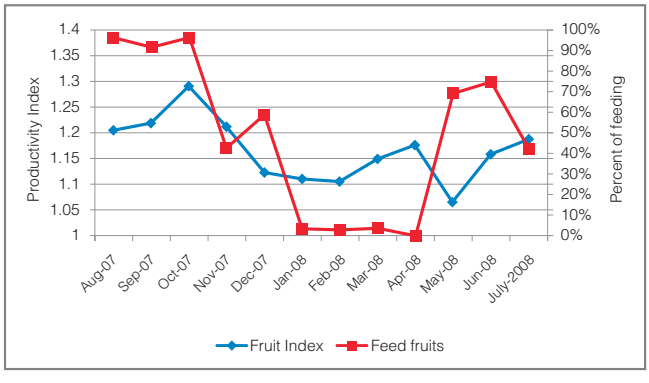

Fig.7. Correlation between 'Fruit Index' and monthly fed fruits (r_s = 0.52).

Plant species in the diet

In total, 166 plant species were identified as diets of the langurs (see Appendix: Table 2 and 3). The feeding list comprises 115 species identified on food remains and 51 species identified during direct observation. Among the 166 plant species, 89 species were found in the vegetation transect and 77 species not. This suggests that the langurs feed on quite a diverse amount of plant species since there were 344 plant species identified in the vegetation transects. The langurs ate leaves of 109 species (65%), fruits of 49 species (29%) and both the fruit and leaves of 23 species (13%).

The 166 plant species belong to 40 plant different families. The top 10 plant families comprise 59% of all species in the feeding list. There were 16 families that only had one species in the feeding list. There were three plant families that provided the most important food for the langurs: Moraceae, Fagaceae and Myrtaceae.

Moraceae and Fagaceae have the largest number of food plant species at 15. The langurs ate leaves of 11 Moraceae species and the fruit of 7 species. The two species *Ficus superba* and *Ficus annulata* were among the top 10 most eaten species having the langurs consume both the leaves and fruit. In the family Fagaceae, the langurs ate the leaves of 8 species and the fruit of 5 Fagaceae species. There were no species belonging to Fagaceae in the top 10 most eaten species.

Myrtaceae ranked third in the overall diversity of feeding species with 11 species. Three species *Syzygium cumini*, *Syzygium petelotii*, and *Syzygium oblatum* of this family were among the top 10

most eaten plant species. The langurs ate mainly leaves of *Syzygium cumini* and *Syzygium petelotii*, while they ate both leaves and fruits of *Syzygium oblatum*.

Based on 473 direct observations on feeding, a list of the top 10 species most eaten by the langurs was analysed. The top species are *Pometia pinnata, Camellia furfuraceae, Syzygium cumini, Quercus fructisepta, Syzygium petelotii, Syzygium oblatum, Xanthophyllum colubrinum, Ficus superba, Ficus annulata*, and *Syzygium polyanthum* (see Appendix: Table 4). The species Pometia pinnata, in the family Sapindaceae was the most eaten plant with the proportion of feeding 14.38%. Although the species only occurred at a density of 1.4 trees/ha. The langurs only fed on young leaves of this plant species. The species *Timonius jambosella*, family Rubiaceae was the least eaten plant with feeding proportion at only 0.21%.

Most food plants occur at a density of less than 10 trees/ha, except *Syzygium cumini* (14.3 trees/ha), *Nephelium melliferum* (14.3 trees/ha), *Garcinia oligantha* (14.8 trees/ha) and *Grewia bulot* (11.5 trees/ha).

Selection ratios

A particular food may be "selected" to consume more often than would be expected from the species' density if: (1) it is available for a long period of time, (2) it occurs at high density on an individual tree, or (3) the animal prefers it to other foods (Clutton-Brook 1975).

In this study, selection ratios for each feeding species were compared in terms of density and dominance (see Appendix: Table 5). This was calculated base on 473 observations (53% of total observations) of which the plant species eaten by the langurs could be identified. The selection ratio could not calculate the species identified from food remains because we did not know the exact time that the langurs spent on eating these species.

Using a selection ratio based on stem density, *Pometia pinnata* was the most selected plant species in the diet of the langurs with the selection ratio value 59.4. On average, there was only 1.4 trees/ha of *Pometia pinnata* in the study site. The least selected species was *Grewia bulot* with the selection ratio value 0.2. On average, there were 11.5 trees/ha of *Grewia bulot* in the study site but using a selection ratio base on basal area, *Syzygium petelotii* was the most selected species with selection ratio value of 129.2. *Grewia bulot* was the least selected species with the selection ratio value of 0.2.

There was no correlation between percent of time feeding on a species and stem density of the same species (r_s= - 0.035, p=0.86). There was also no correlation between percent of time feeding on species and total basal area of the species (r_s= - 0.075, p=0.71). This suggests that neither the density nor dominance of trees in the forest influences the choice of feeding tree. In fact, species such as *Garcinia oligantha*, *Nephelium melliferum*, and *Grewia bulot* were quite abundant in the study site but the langurs seldom fed on these species. Conversely, species such as *Pometia pinnata* and *Ficus superba* were very rare in terms of stem density, but the langurs fed on these species quite often. In the middle, *Syzygium cumini* was eaten quite often and was quite abundant at the site. The nutrition value of food items (young leaves, fruits, and seeds) that the tree species provide might be a more important factor to influence the choice of the tree species.

Comparison of food species, tree families and its availability in the forest

A list of the top 10 most eaten plant families was calculated based on direct observations. The list of top 10 most diverse families in the feeding list was calculated based on direct observations and food remains. A comparison of the top 10 most eaten plant families and the top 10 most important families in two types of forests (Table 6):

Table 6. Comparison of the top 10 most density families in the feeding list and the top 10 families most important in the habitat of both forest types. FIV: Family Important Value.

No.	Family	No. of feeding species	Forest type 1	FIV	Forest type 2	FIV
1	**Fagaceae**	15	**Moraceae**	30.11	**Fagaceae**	38.31
2	**Moraceae**	15	**Myrtaceae**	25.93	**Euphorbiaceae**	34.00
3	**Myrtaceae**	11	**Lauraceae**	25.90	Sapindaceae	23.90
4	**Euphorbiaceae**	10	**Fagaceae**	24.23	**Lauraceae**	23.10
5	**Guttiferae**	10	**Euphorbiaceae**	23.99	**Guttiferae**	19.77
6	**Lauraceae**	9	Sapindaceae	21.78	**Myrtaceae**	19.71
7	**Meliaceae**	8	**Guttiferae**	20.01	**Moraceae**	15.34
8	Elaeocarpaceae	7	**Theaceae**	11.26	**Meliaceae**	12.68
9	**Sapotaceae**	7	**Sapotaceae**	11.03	Rubiaceae	10.39
10	**Theaceae**	7	**Rubiaceae**	9.65	Magnoliaceae	9.23

Type 1: Closed evergreen, lower montane moist sub-tropical forest.

Type 2: Mixed broad-leaf and needled-leaf, lower montane moist sub-tropical forest.

As a result, it revealed that 8 out of 10 most important families in the forest Type 1 overlap with the top 10 densest families in the feeding list. For the forest Type 2, 7 out of 10 most important plant families were overlapping with top 10 densest families in the feeding list (Table 7).

Table 7. Comparison of the top 10 most feeding families and the stem density of the top 10 most families in both forest types.

No.	Family	Feeding (%)	Forest type 1	Density (%)	Forest type 2	Density (%)
1	Myrtaceae	21.8	Myrtaceae	10.32	Euphorbiaceae	11.43
2	Sapindaceae	17.5	Sapindaceae	9.81	Lauraceae	9.67
3	Moraceae	14.8	Euphorbiaceae	8.54	Sapindaceae	9.01
4	Theaceae	9.1	Lauraceae	8.15	Guttiferae	8.79
5	Fagaceae	8.9	Moraceae	7.39	Fagaceae	7.03
6	Guttiferae	3.4	Guttiferae	7.13	Myrtaceae	6.81
7	Flacourtiaceae	3.2	Fagaceae	7.01	Moraceae	5.71
8	Tiliaceae	3.2	Rubiaceae	3.82	Rubiaceae	3.96
9	Alangiaceae	3.0	Theaceae	3.82	Meliaceae	3.74
10	Loranthaceae	3.0	Sapotaceae	3.57	Annonaceae	3.30

For example, the langurs ate 15 species of Moraceae. Moraceae was also among the most important in the forest Type 1 (ranked 1st, Table 6) and in the forest Type 2 (ranked 7th, Table 6). The langurs ate 15 species of Fagaceae and this family was also the most important family in the forest Type 2 and ranked as 4th in the forest Type 1 (Table 6). This means that the langurs exploited the plant species which belong to the most important families in the habitat. Noted that the 'Family Important Value' (FIV) indicates that the families are not only diverse, but also have a higher stem density and are the most dominant at the site. This is a sign that food resources in both types of forests are quite sufficient to support long term survival of the doucs. And the langurs have adapted very well to their habitat. The top 20 most consumed species were compared with top 20 species most abundant in two forest types (see Appendix: Table 8). There was an important overlap between feeding species and the most abundant species in each forest. For example, the species *Syzygium cumini*, which was eaten in high proportion by the langurs, (ranked 3rd, Table 8) was quite abundant in the forest Type 1 (ranked 3rd). The *Garcinia oligantha* was quite abundant in forest Type 2 (ranked 2nd, Table 8) and was also often consumed by the langurs (ranked 12th, Table 4). In particular, *Xerospermum*

noronhianum, the most abundant species in the both forest types, was eaten by the langurs, although, they fed a very little amount on this species. This suggests that the langurs exploited the abundant food resources in the site at the species level and the habitat could provide sufficient food to the grey-shanked douc langur population. This could be explained in that due to the abundance of food resources the doucs do not need to compete between the members of the group. In fact, the grey-shanked douc langurs can gather in a big troop of up to 100 individuals.

Discussion

Comparison of food items among the odd-nosed monkey group

The odd-nosed monkey group comprised of 10 species and 4 genera *Pygathrix*, *Rhinopithecus Nasalis* and *Simias* is distributed only in Southeast Asia and Southwest China (Groves 2001). The study on feeding ecology of *Pygathrix* and *Rhinopithecus* was not focused on until China and Vietnam opened their countries to foreign scientists in the 1990's.

Within the genus *Pygathrix*, Pham Nhat (1993) reported that the diet of red-shanked douc langurs in Phong Nha-Ke Bang National Park comprised 63% of leaves and 37% of fruits. Lippold (1998) also reported that the red-shanked douc langurs in Son Tra, Danang feed mostly leaves (82%) and relatively low amount of fruits and seeds (14%). However, these studies were conducted only in a very short period. The diet of red-shanked douc langurs in captivity was studied on a semi-wild area at the Endangered Primate Rescue Center, Cuc Phuong National Park Otto (2005). Up to 62% leaves, 13% fruits and 25% flowers were recorded. Diet of the black shanked douc langur (*P. nigripes*) was reported in two long-term research studies, one in Cambodia (Rawson 2006) and one in Vietnam (Hoang Minh Duc 2009). Rawson reported for the black-shanked douc langurs an amount of 39.9%, leaves, 11.5% fruits and a remarkable proportion of seeds with 39.7%. Hoang Minh Duc listed for the black-shanked douc langurs in the Nui Chua and Binh Phuoc National Parks an amount of 54.6% leaves, 29.3% fruits and 14.5% flowers.

In the presented study, the grey-shanked douc langurs fed on 58.8% leaves and 40.1% fruits and seeds. In comparison to the other two douc langur species the grey-shanked douc langurs eat more leaves than the black-shanked douc langurs ($\bar{x}$= 47.2%) but less than red-shanked douc langurs ($\bar{x}$= 72%). And they ate fruits including seeds more than red-shanked douc langurs ($\bar{x}$= 18.4%) and the same proportion like the black-shanked douc langurs ($\bar{x}$= 40%).

It is to conclude, that all three douc langur species have a significant amount of fruit and seeds in their diet (range from 18.4% to 40.1%). But, the amount of leaves is still substantial when compared to other foodstuffs in their diets (from 39.9% to 87.8%)(see Appendix: Table 9). Chivers (1994) suggested that the genus *Pygathrix*, despite its low body weight, would appear to be in the more folivorous category. This data revealed that the diet of *Pygathrix* is more flexible. In a manner of speaking they have an intermediary position of folivorous and frugivorous, a flexible diet and consume a high proportion of fruits and seeds.

Within the genus *Rhinopithecus*, there are two different patterns of diet (Table 9). The snub-nosed monkeys including the Yunnan snub-nosed monkey (*R. bieti*), the golden snub-nosed monkey (*R. roxellana*), lichens appeared to be vital food type to these species, specially for the populations that live in conifer forest habitat (Kirkpatrick et al. 1998; Ding & Zhao 2004; Zuo-Fu Xiang et al. 2007). As an example, *R. bieti* fed heavily on lichens, up to 86% of the diet. In contrast, the Guizhou snub-nosed monkey (*R. breilichi*), the black snub-nosed monkey (*R. strykeri*) and the Tonkin snub-nosed monkey (*R. avunculus*) have remarkable diverse and flexible diet. Leaves and fruits were eaten in higher proportions ($\bar{x}$ = 50%) and ($\bar{x}$ = 29.4%), respectively (Bleisch et al. 1993; Yang et al. 2019; Boonratana & Le Xuan Canh 1998; Dong Thanh Hai 2008). Probably, richness of plant species in the tropical and sub-tropical habitat led to the diet of *R. brelichi*, *R. strykeri*, and *R. avunculus* more divers and flexible than the diet of *R. roxellana* and *R. bieti* in poor habitat.

The sole species in the genus *Nasalis*, the proboscis monkey (*N. larvatus*) consumed a high proportion of leaves ($\bar{x}$ = 58.2%) and fruits ($\bar{x}$ = 29.5%) while other plant parts were eaten in a low proportion (Table 9). Matsuda et al. (2009) described the fruit eating habit of proboscis monkeys in Menanggul River, Sabah, Malaysia as follow: the monkeys devoted 25.9% to feeding on fruits and

unripe fruits accounted for 90.4%. Seeds and fruit flesh accounted for 64.1% of unripe fruits, while only seeds were fed on ripe fruits.

In general, the diet component and proportion of plant parts in the diet of douc langurs is rather similar to that of *Nasalis* than *Rhinopithecus*. Douc langurs and proboscis monkeys feed mostly on leaves and fruits. These species live in tropical forests in Southeast Asia with high food plant diversity.

Seasonal changes of food items

Van Schaik et al. (1993) suggested that there are six types of responses that primates might exhibit during a food scarcity period: (1) occasional famine and mass mortality, (2) dietary switching, (3) seasonal breeding, (4) seasonal movement, (5) altitudinal migration, and (6) hibernation. Many primates adapt to a dietary switching strategy when they face seasonal food scarcity.

The grey-shanked doucs in this study changed their diet component significantly following the seasonal availability of food items which they mainly feed on. In the dry season, the doucs fed mostly on young leaves (82%) and they ate a very low proportion of mature leaves (5.1%) and fruits (12.1%). In the wet season, the langurs fed extensively on fruits (~70%), mature leaves (12.8%), but a small proportion on young leaves (17.9%). In fact, when the young leaves became scarce, they switched their habits and fed on fruits, seeds and mature leaves which were more available during the wet season.

Evidence from other taxa of primates was also available. Stone (2007) reported that squirrel monkeys living in the Amazon forest remarkably change their diet components in different seasons. The squirrel monkeys feed mostly on insects ($\bar{x} > 50\%$) and small amount of fruits, seeds and flowers. In the dry season, the monkeys consume high number of insects (79%) as their abundance is quite high. However, when insect abundance decreases in the wet season, they shift to feed more on fruits, seeds and flowers.

Diet and food availability

Diet and dietary breadth are important factors influencing the ability of primates to survive (Wong et al. 2006) while quality and quantity of food available especially during the period of food scarcity are important factors that determine primate population carrying capacity of the habitat (Gautier-Hion et al. 2002).The diet of the grey-shanked douc langurs in Kon Ka Kinh National Park show that the monkeys have a remarkable wide range of food plants at both the species and family level. How this wide range of plants match with the food plant availability in the habitat is an interesting question. So, the list of the monkey's diet and the list of the most dominant family in the habitat were compared. It revealed that almost all of the food plants that the langurs fed on were quite abundant in the habitat. For example, the top 3 most eaten families Myrtaceae, Sapindaceae, and Moraceae were found significantly abundant in both types of forests where the langurs live. Myrtaceae ranked 1st in the forest Type 1 and 6th in the forest Type 2. Sapindaceae ranked 2nd in the forest Type 1 and 3rd in the forest Type 2. Moraceae ranked 5th in forest Type 2 and 7th in the forest Type 2. So, in terms of quantity, the habitat of the grey-shanked douc langurs in the Kon Ka Kinh National Park is highly capable to support the species.

The quality of habitat is another important factor to assess the carrying capacity of habitat (Davies 1994). This was not measured in this research project. Further study on nutritional value of food items from young leaves to mature leaves, as well as fruits and seeds at this study site are necessary.

Important of research food remains

Among the 166 species identified as food plants of the grey-shanked doucs, 115 species were identified base on food remains. In the field, limited visual condition often prevented the ability to number all feeding trees of the langurs, so the study of foodstuffs remains in order to provide essential information of diet composition. This method was found useful in another field research as well. For example, the study of diet composition of *Rhinopithecus bieti* based on food remains and feces samples resulted in a list of 59 plant species, 42 genera and 28 families (Ding & Zhao 2004). Data on the diet of chimpanzees in forest of Kahuzi is comprised of 114 species from 57 plant families and was also analysed based on food remains and feces samples (Basabose 2002).

The diet of the grey-shanked douc langurs in the Kon Ka Kinh National Park contains mostly of young leaves and quite a significant amount of fruits. Seasonal changes affect the food items that the doucs eat on a monthly basis. There were 166 species of plants eaten by the grey-shanked douc langurs and the habitat of the species is highly capable in supporting the species.

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Appendix

Table 2. List of food trees species eaten by the grey-shanked douc langurs. Fruits are combined ripe and unripe fruits.

No.	Species	Family	Food remains	Observation	Leave	Fruit	Unclassified
1	*Acer flabellatum*	Aceraceae	x		x		
2	*Saurauia roxburghii*	Actinidiaceae	x				x
3	*Alangium salvifolium*	Alangiaceae		x	x	x	
4	*Buchanania lucida*	Anacardiaceae	x		x		
5	*Pegia sarmentosa*	Anacardiaceae	x			x	
6	*Polyalthia jenkinsii*	Annonaceae	x		x		
7	*Schefflera bodinieri*	Araliaceae	x		x		
8	*Schefflera crassibracteata*	Araliaceae	x		x		
9	*Schefflera leroyiana*	Araliaceae	x		x		
10	*Schefflera pes-avis*	Araliaceae	x			x	
11	*Schefflera poilaneana*	Araliaceae	x		x		
12	*Schefflera trungii*	Araliaceae		x	x	x	
13	*Betula alnoides*	Betulaceae	x		x		
14	*Acrodes dungii*	Burseraceae	x		x		
15	*Canarium bengalense*	Burseraceae		x		x	
16	*Canarium littorale*	Burseraceae	x		x	x	
17	*Cassia javanica*	Caesalpinioideae		x	x	x	
18	*Capparis eurycibe*	Capparaceae	x		x		
19	*Capparis grandis*	Capparaceae	x			x	
20	*Capparis rigida*	Capparaceae	x			x	
21	*Rourea minor*	Capparaceae	x			x	
22	*Masticia arborea*	Cornaceae	x			x	
23	*Dipterocarpus obtusifolius*	Dipterocarpaceae	x				x
24	*Dipterocarpus turbinatus*	Dipterocarpaceae	x				x
25	*Diospyros bangoiensis*	Ebenaceae	x		x	x	
26	*Diospyros crumenata*	Ebenaceae	x				x
27	*Elaeocarpus darlacensis*	Elaeocarpaceae	x		x		
28	*Elaeocarpus grandiflora*	Elaeocarpaceae		x	x		
29	*Elaeocarpus grumosus*	Elaeocarpaceae	x		x	x	
30	*Elaeocarpus harmandii*	Elaeocarpaceae	x		x		
31	*Elaeocarpus hygrophilous*	Elaeocarpaceae		x	x		

32	*Elaeocarpus kontumensis*	Elaeocarpaceae	x		x		
33	*Elaeocarpus petelotii*	Elaeocarpaceae	x		x		
34	*Actephila excelsa*	Euphorbiaceae	x		x		
35	*Actephila anthelmintica*	Euphorbiaceae	x		x		
36	*Bischofia javanica*	Euphorbiaceae	x		x		
37	*Drypetes assamica*	Euphorbiaceae	x				x
38	*Endospermum chinense*	Euphorbiaceae	x		x		
39	*Oligoceras eberhardtii*	Euphorbiaceae	x				x
40	*Ostodes paniculata*	Euphorbiaceae	x		x		
41	*Phyllanthus lingulatus*	Euphorbiaceae	x				x
42	*Sapium discolor*	Euphorbiaceae	x		x		
43	*Trigonostemon annamensis*	Euphorbiaceae		x	x	x	
44	*Castanopsis recurira*	Fagaceae	x		x		
45	*Castanopsis wilsonii*	Fagaceae	x				x
46	*Lithocarpus chevalier*	Fagaceae	x		x		
47	*Lithocarpus gymnocarpus*	Fagaceae		x		x	
48	*Lithocarpus kontumensis*	Fagaceae	x		x	x	
49	*Lithocarpus megastachyus*	Fagaceae	x		x		
50	*Lithocarpus microbalanus*	Fagaceae	x		x		
51	*Lithocarpus pariei*	Fagaceae	x		x	x	
52	*Lithocarpus rhabdistachyus*	Fagaceae	x				x
53	*Lithocarpus toumorangensis*	Fagaceae	x		x		
54	*Quercus edithae*	Fagaceae	x				x
55	*Quercus fructisepta*	Fagaceae		x		x	
56	*Quercus macrocalyx*	Fagaceae	x				x
57	*Quercus setulosa*	Fagaceae		x		x	
58	*Quercus throrelii*	Fagaceae	x		x		
59	*Casearia annamensis*	Flacourtiaceae	x		x		
60	*Casearia membranacea*	Flacourtiaceae	x		x		
61	*Homalium ceylanicaum*	Flacourtiaceae		x	x		
62	*Hydnocarpus annamensis*	Flacourtiaceae		x		x	
63	*Hydnocarpus kurzii*	Flacourtiaceae		x	x		
64	*Garcinia lanessanii*	Guttiferae	x			x	
65	*Calophyllum dongnaiensis*	Guttiferae	x			x	
66	*Calophyllum rugosum*	Guttiferae	x			x	
67	*Calophyllum tetrapterum*	Guttiferae	x		x		
68	*Garcinia tinctoria*	Guttiferae	x			x	
69	*Garcinia oblongifolia*	Guttiferae	x		x		
70	*Garcinia oligantha*	Guttiferae		x	x	x	
71	*Garcinia schefferi*	Guttiferae	x		x		

72	*Garcinia vilersiana*	Guttiferae	x			x	
73	*Mesua ferruginea*	Guttiferae	x		x		
74	*Beilschmiedia yannanensis*	Lauraceae	x		x		
75	*Cinnamomum bonii*	Lauraceae		x			x
76	*Cinnamomum glaucescens*	Lauraceae	x		x		
77	*Cryptocarya metcalfiana*	Lauraceae		x		x	
78	*Dehaasia caesia*	Lauraceae	x		x	x	
79	*Lindera annamensis*	Lauraceae	x		x		
80	*Litsea baviensis*	Lauraceae	x		x		
81	*Litsea variabilis*	Lauraceae		x	x		
82	*Phoebe attenuata*	Lauraceae		x	x		
83	*Strychnos umbellata*	Loganiaceae		x		x	
84	*Macrosolen dianthus*	Loranthaceae		x	x		
85	*Michelia constricta*	Magnoliaceae	x		x		
86	*Michelia mediocris*	Magnoliaceae	x				x
87	*Michelia subulifera*	Magnoliaceae	x		x		
88	*Paramechelia baillonii*	Magnoliaceae		x		x	
89	*Memecylon chevalieri*	Melastomataceae		x	x		
90	*Aglaia annamensis*	Meliaceae	x				x
91	*Aglaia lawii*	Meliaceae	x		x		
92	*Aglaia verrucosa*	Meliaceae		x	x		
93	*Dysoxylum juglans*	Meliaceae	x		x		
94	*Dysoxylum excelsum*	Meliaceae	x			x	
95	*Walsura elata*	Meliaceae		x		x	
96	*Walsura robusta*	Meliaceae	x		x		x
97	*Walsura vilosa*	Meliaceae	x		x		
98	*Artocarpus gomezianus*	Moraceae	x		x		
99	*Artocarpus lakoocha*	Moraceae		x	x	x	
100	*Artocarpus melinoxyla*	Moraceae	x		x		
101	*Artocarpus rigida*	Moraceae	x				x
102	*Artocarpus styracifolia*	Moraceae	x		x		
103	*Brosimum galactodendron*	Moraceae	x		x	x	
104	*Ficus amplissima*	Moraceae		x			x
105	*Ficus annulata*	Moraceae		x	x	x	
106	*Ficus callophylla*	Moraceae	x		x		x
107	*Ficus callosa*	Moraceae		x	x		
108	*Ficus hederacea*	Moraceae		x		x	
109	*Ficus superba*	Moraceae		x	x	x	
110	*Ficus talbotii*	Moraceae	x		x		
111	*Ficus tinctoria*	Moraceae		x	x	x	

112	*Ficus vasulosa*	Moraceae		x		x	
113	*Knema globularia*	Myristicaceae	x		x	x	
114	*Acmena acuminatissimum*	Myrtaceae	x				x
115	*Harpullia cupanioides*	Myrtaceae	x		x		
116	*Syzygium aromaticum*	Myrtaceae	x		x		
117	*Syzygium circumcissa*	Myrtaceae	x				x
118	*Syzygium cumini*	Myrtaceae		x	x		
119	*Syzygium oblatum*	Myrtaceae		x	x	x	
120	*Syzygium pachysarcum*	Myrtaceae		x	x		
121	*Syzygium petelotii*	Myrtaceae		x	x		
122	*Syzygium polyanthum*	Myrtaceae		x		x	
123	*Syzygium tinctorium*	Myrtaceae	x				x
124	*Syzygium tramnion*	Myrtaceae		x	x		
125	*Bulbophyllum guttulatum*	Orchidaceae	x				x
126	*Dendrobium chlorostylum*	Orchidaceae	x		x		
127	*Podocarpus neriifolius*	Podocarpaceae		x	x		
128	*Sorbus granulosa*	Rosaceae	x		x		
129	*Adina thanhoaensis*	Rubiaceae	x				x
130	*Canthium dicoccum*	Rubiaceae	x		x		
131	*Psychotria sarmentosa*	Rubiaceae	x		x		
132	*Tarenna collinsae*	Rubiaceae	x				x
133	*Timonius jambosella*	Rubiaceae		x	x		
134	*Dimocarpus longan*	Sapindaceae	x				x
135	*Litchi sinensis*	Sapindaceae		x	x	x	
136	*Nephelium lappaceum*	Sapindaceae	x				x
137	*Nephelium melliferum*	Sapindaceae		x		x	
138	*Pometia pinnata*	Sapindaceae		x	x	x	
139	*Xerospermum noronhianum*	Sapindaceae	x				x
140	*Madhuca elliptica*	Sapotaceae	x		x		
141	*Madhuca subquiconcialis*	Sapotaceae		x	x		
142	*Palaquium annamensis*	Sapotaceae	x		x		
143	*Palaquium elliptica*	Sapotaceae	x				x
144	*Palaquium obovatum*	Sapotaceae	x				x
145	*Sarcosperma affinis*	Sapotaceae	x		x		
146	*Sarcosperma laurinum*	Sapotaceae	x		x		
147	*Ailanthus altissima*	Simaroubaceae	x		x		
148	*Ailanthus integrifolia*	Simaroubaceae		x			x
149	*Rehderodendron kweichowense*	Styraceae	x				
150	*Pyrenaria jonqueriana*	Theaceae		x	x		
151	*Camellia assimilis*	Theaceae	x				

152	*Camellia furfuraceae*	Theaceae		x	x	x	
153	*Camellia tsai*	Theaceae		x	x		
154	*Eurya trichocarpa*	Theaceae	x		x		
155	*Gordonia bidoupensis*	Theaceae	x		x		
156	*Ternstroemia kwangtungensis*	Theaceae		x	x		
157	*Colona nubla*	Tiliaceae		x	x		
158	*Grewia bulot*	Tiliaceae		x		x	
159	*Grewia calophylla*	Tiliaceae	x		x	x	
160	*Vitex leptobotrys*	Verbenaceae		x	x		
161	*Cissus rosea*	Vitaceae	x				x
162	*Parthenoissus landuk*	Vitaceae	x		x		
163	*Tetrastigma godefroyanum*	Vitaceae	x		x		
164	*Tetrastigma heterophyllum*	Vitaceae	x		x		
165	*Tetrastigma petelotii*	Vitaceae	x		x	x	
166	*Xanthophyllum colubrinum*	Xanthophyllaceae		x	x		
		Total	115	51	109	49	31

Table 3. List of plant families eaten by the grey-shanked douc langurs with percentage of feeding leaves and fruits, based on direct observation and food remains.

No.	Family	No. of species	%	No. of species langurs ate leaf	%	No. of species langurs ate fruit	%
1	Moraceae	15	9.0	11	10.1	7	14.3
2	Fagaceae	15	9.0	8	7.3	5	10.2
3	Myrtaceae	11	6.6	7	6.4	2	4.1
4	Guttiferae	10	6.0	5	4.6	6	12.2
5	Euphorbiaceae	10	6.0	7	6.4	1	2.0
6	Lauraceae	9	5.4	7	6.4	2	4.1
7	Meliaceae	8	4.8	5	4.6	2	4.1
8	Elaeocarpaceae	7	4.2	7	6.4	1	2.0
9	Theaceae	7	4.2	6	5.5	1	2.0
10	Sapotaceae	7	4.2	5	4.6	0	0.0
11	Sapindaceae	6	3.6	2	1.8	3	6.1
12	Araliaceae	6	3.6	5	4.6	2	4.1
13	Flacourtiaceae	5	3.0	4	3.7	1	2.0
14	Vitaceae	5	3.0	4	3.7	1	2.0
15	Rubiaceae	5	3.0	3	2.8	0	0.0
16	Capparaceae	4	2.4	1	0.9	3	6.1
17	Magnoliaceae	4	2.4	2	1.8	1	2.0
18	Burseraceae	3	1.8	2	1.8	2	4.1

Table 3. continuation

19	Tiliaceae	3	1.8	2	1.8	2	4.1
20	Anacardiaceae	2	1.2	1	0.9	1	2.0
21	Ebenaceae	2	1.2	1	0.9	1	2.0
22	Orchidaceae	2	1.2	1	0.9	0	0.0
23	Simaroubaceae	2	1.2	1	0.9	0	0.0
24	Dipterocarpaceae	2	1.2	0	0.0	0	0.0
25	Alangiaceae	1	0.6	1	0.9	1	2.0
26	Caesalpinioideae	1	0.6	1	0.9	1	2.0
27	Myristicaceae	1	0.6	1	0.9	1	2.0
28	Cornaceae	1	0.6	0	0.0	1	2.0
29	Loganiaceae	1	0.6	0	0.0	1	2.0
30	Aceraceae	1	0.6	1	0.9	0	0.0
31	Annonaceae	1	0.6	1	0.9	0	0.0
32	Betulaceae	1	0.6	1	0.9	0	0.0
33	Loranthaceae	1	0.6	1	0.9	0	0.0
34	Melastomataceae	1	0.6	1	0.9	0	0.0
35	Podocarpaceae	1	0.6	1	0.9	0	0.0
36	Rosaceae	1	0.6	1	0.9	0	0.0
37	Verbenaceae	1	0.6	1	0.9	0	0.0
38	Xanthophyllaceae	1	0.6	1	0.9	0	0.0
39	Actinidiaceae	1	0.6	0	0.0	0	0.0
40	Styraceae	1	0.6	0	0.0	0	0.0
	Total	166		109		49	

Table 4. Annual percentage of time spent feeding on specific food items based on direct observations (n=473).

No.	Species	Family	Young leaves %	Mature leaves %	Unripe fruit %	Ripe fruit %	Total %
1	*Pometia pinnata*	Sapindaceae	14.38				**14.38**
2	*Camellia furfuraceae*	Theaceae	0.85		0.42	6.34	**7.61**
3	*Syzygium cumini*	Myrtaceae	7.61				**7.61**
4	*Quercus fructisepta*	Fagaceae			6.77		**6.77**
5	*Syzygium petelotii*	Myrtaceae	1.69		2.54		**4.23**
6	*Syzygium oblatum*	Myrtaceae				3.81	**3.81**
7	*Xanthophyllum colubrinum*	Xanthophyllaceae			3.81		**3.81**
8	*Ficus superba*	Moraceae		0.63	2.75		**3.38**
9	*Ficus annulata*	Moraceae	2.54		0.21	0.42	**3.17**
10	*Syzygium polyanthum*	Myrtaceae				3.17	**3.17**

Table 4. continuation

11	*Macrosolen dianthus*	Loranthaceae	1.48		1.27		2.75
12	*Garcinia oligantha*	Guttiferae	1.06		1.27	0.42	2.75
13	*Artocarpus lakoocha*	Moraceae	1.69		0.85		2.54
14	*Colona nubla*	Tiliaceae	2.54				2.54
15	*Ficus vasulosa*	Moraceae				2.33	2.33
16	*Schefflera trungii*	Araliaceae	0.21			2.11	2.33
17	*Alangium salvifolium*	Alangiaceae	1.27		0.42		1.69
18	*Hydnocarpus kurzii*	Flacourtiaceae	1.69				1.69
19	*Ficus amplissima*	Moraceae	0.42		1.06		1.48
20	*Phoebe attenuata*	Lauraceae			0.21	1.27	1.48
21	*Quercus setulosa*	Fagaceae			1.48		1.48
22	*Homalium ceylanicaum*	Flacourtiaceae	0.42	0.85			1.27
23	*Canarium bengalense*	Burseraceae				1.27	1.27
24	*Elaeocarpus grandiflora*	Elaeocarpaceae	1.27				1.27
25	*Nephelium melliferum*	Sapindaceae				1.27	1.27
26	*Strychnos umbellata*	Loganiaceae	1.27				1.27
27	*Syzygium tramnion*	Myrtaceae	0.85		0.21	0.21	1.27
28	*Alangium ridlay*	Alangiaceae				1.06	1.06
29	*Madhuca subquiconcialis*	Sapotaceae	1.06				1.06
30	*sp3*	sp3	1.06				1.06
31	*Camellia tsai*	Theaceae		0.85			0.85
32	*Ficus hederacea*	Moraceae				0.85	0.85
33	*Podocarpus neriifolius*	Podocarpaceae	0.63			0.21	0.85
34	*Pyrenaria jonqueriana*	Thaceae	0.85				0.85
35	*Vitex leptobotrys*	Verbenaceae	0.42			0.21	0.63
36	*Litchi sinensis*	Sapindaceae	0.63				0.63
37	*Garcinia cf. tinctoria*	Guttiferae				0.42	0.42
38	*Grewia bulot*	Tiliaceae	0.42				0.42
39	*Litsea variabilis*	Lauraceae	0.42				0.42
40	*sp1*	sp1			0.42		0.42
41	*Walsura elata*	Meliaceae	0.42				0.42
42	*Cryptocarya metcalfiana*	Lauraceae				0.21	0.21
43	*Elaeocarpus japonicus*	Elaeocarpaceae			0.21		0.21
44	*Paramechelia baillonii*	Magnoliaceae				0.21	0.21
45	*sp2*	sp2	0.21				0.21
46	*sp4*	sp4	0.21				0.21
47	*Syzygium pachysarcum*	Myrtaceae		0.21			0.21
48	*Timonius jambosella*	Rubiaceae		0.21			0.21

Table 5. Selection ratios (SR) for all plant species in the annual diet of the grey-shanked douc langurs.
SDSR: Selection ratio based on stem density; BASR: Selection ratio based on basal area; N/A: the species did not appear along the tree enumeration transects.

No.	Species	Feeding time (%)	Density (tree/ha)	Density (%)	SDSR	Basal area (%)	BASR
1	*Pometia pinnata*	14.4	1.4	0.24	59.4	0.72	19.9
2	*Camellia furfuraceae*	7.6	N/A	N/A	N/A	N/A	N/A
3	*Syzygium cumini*	7.6	14.3	2.42	3.1	1.57	4.8
4	*Quercus fructisepta*	6.8	.	.	.	.	.
5	*Syzygium petelotii*	4.2	1.4	0.24	17.5	0.03	129.2
6	*Syzygium oblatum*	3.8	3.3	0.56	6.7	0.30	12.6
7	*Xanthophyllum colubrinum*	3.8	.	.	.	.	.
8	*Ficus superba*	3.4	0.5	0.08	41.9	0.21	16.3
9	*Ficus annulata*	3.2	.	.	.	.	.
10	*Syzygium polyanthum*	3.2	.	.	.	.	.
11	*Macrosolen dianthus*	2.7	.	.	.	.	.
12	*Artocarpus lakoocha*	2.5	1.9	0.32	7.9	0.18	14.3
13	*Colona nubla*	2.5	.	.	.	.	.
14	*Ficus vasulosa*	2.3	.	.	.	.	.
15	*Schefflera trungii*	2.3	.	.	.	.	.
16	*Garcinia oligantha*	2.7	14.8	2.50	1.1	1.47	1.9
17	*Alangium salvifolium*	1.7	0.9	0.16	10.5	0.64	2.7
18	*Hydnocarpus kurzii*	1.7	8.6	1.45	1.2	0.31	5.5
19	*Ficus amplissima*	1.5	1.4	0.24	6.1	0.70	2.1
20	*Phoebe attenuata*	1.5	4.3	0.73	2.0	0.55	2.7
21	*Quercus setulosa*	1.5	0.5	0.08	18.4	0.03	44.4
22	*Canarium bengalense*	1.3	.	.	.	.	.
23	*Elaeocarpus grandiflora*	1.3	0.5	0.08	15.7	0.26	4.8
24	*Homalium ceylanicaum*	1.3	.	.	.	.	.
25	*Nephelium melliferum*	1.3	14.3	2.42	0.5	1.47	0.9
26	*Strychnos umbellata*	1.3	0.9	0.16	7.9	0.10	12.4
27	*Syzygium tramnion*	1.3	2.4	0.40	3.1	0.38	3.3
28	*Alangium ridlay*	1.1	.	.	.	.	.
29	*Madhuca subquiconcialis*	1.1	0.9	0.16	6.6	0.08	13.3
30	*Camellia tsai*	0.8	0.5	0.08	10.5	0.08	10.7
31	*Ficus hederacea*	0.8	.	.	.	.	.
32	*Podocarpus neriifolius*	0.8	3.3	0.56	1.5	1.27	0.7
33	*Pyrenaria jonqueriana*	0.8	.	.	.	.	.
34	*Litchi sinensis*	0.6	1.9	0.32	2.0	0.59	1.1
35	*Vitex leptobotrys*	0.6	.	.	.	.	.

36	*Garcinia tinctoria*	0.4	0.9	0.16	2.6	0.18	2.3
37	*Grewia bulot*	0.4	11.5	1.94	0.2	2.05	0.2
38	*Litsea variabilis*	0.4	.	.	.	.	.
39	*Walsura elata*	0.4	2.4	0.40	1.0	0.15	2.8
40	*Cryptocarya metcalfiana*	0.2		.	.	.	.
41	*Elaeocarpus japonicus*	0.2	5.7	0.97	0.2	0.83	0.3
42	*Paramechelia baillonii*	0.2	.	.	.	.	.
43	*Syzygium pachysarcum*	0.2	3.3	0.56	0.4	0.55	0.4
44	*Timonius jambosella*	0.2	2.4	0.40	0.5	0.06	3.3

Table 8. Comparison of the top 20 most feeding species and top 20 most abundant species in both types of forest. DR: Relative Density; DA: Absolute Density.

Top 20 most feeding species		**Forest type 1**				**Forest type 2**			
Species	**feeding time (%)**	**Species**	**No. trees**	**DR**	**DA**	**Species**	**No. trees**	**DR**	**DA**
Pometia pinnata	14.38	*Xerospermum noronhianum*	31	3.95	24	*Xerospermum noronhianum*	25	5.49	31
Camellia furfuraceae	7.61	*Nephelium melliferum*	24	3.06	18	***Garcinia oligantha***	18	3.96	23
Syzygium cumini	7.61	***Syzygium cumini***	24	3.06	18	*Sapium discolor*	11	2.42	14
Quercus fructisepta	6.77	*Grewia bulot*	18	2.29	14	*Lithocarpus kontumensis*	10	2.20	13
Syzygium petelotii	4.23	*Dacryodes cf. dungii*	17	2.17	13	*Diospyros latisepala*	9	1.98	11
Syzygium oblatum	3.81	*Taxotrophis macrophylla*	17	2.17	13	*Litsea rubescens*	9	1.98	11
Xanthophyllum colubrinum	3.81	*Sapium aponicas*	16	2.04	12	*Aporosa ficifolia*	8	1.76	10
Ficus superba	3.38	***Garcinia oligantha***	13	1.66	10	*Glochidion obliquum*	8	1.76	10
Ficus annulata	3.17	*Litsea rubescens*	12	1.53	9	*Xylopia nitida*	8	1.76	10
Syzygium polyanthum	3.17	***Hydnocarpus kurzii***	11	1.40	8	*Buchanania lucida*	7	1.54	9
Macrosolen dianthus	2.75	*Ostodes paniculata*	10	1.27	8	*Cinnamomum durifolium*	7	1.54	9
Garcinia oligantha	2.75	*Canthium dicoccum*	9	1.15	7	***Hydnocarpus kurzii***	7	1.54	9
Artocarpus lakoocha	2.54	*Pterospermum lancaefolium*	9	1.15	7	*Adina thanhoaensis*	6	1.32	8
Colona nubla	2.54	*Beilschmiedia balansae*	8	1.02	6	*Calophyllum dongnaiensis*	6	1.32	8

Table 8. continuation

Ficus vasulosa	2.33	*Elaeocarpus aponicas*	8	1.02	6	*Grewia bulot*	6	1.32	8
Schefflera trungii	2.33	*Lithocarpus leiocarpa*	8	1.02	6	*Memecylon acuminatum*	6	1.32	8
Alangium salvifolium	1.69	*Lithocarpus microbalanus*	8	1.02	6	*Nephelium melliferum*	6	1.32	8
Hydnocarpus kurzii	1.69	*Walsura robusta*	8	1.02	6	***Syzygium cumini***	6	1.32	8
Ficus amplissima	1.48	*Cleistocalyx circumcissa*	7	0.89	5	*Artocarpus cf. styracifolius*	5	1.10	6
Phoebe attenuata	1.48	*Croton tiglium*	7	0.45	5	*Artocarpus gomezianus*	5	1.10	6

Table 9. Comparison of the diet in the odd-nosed monkey group.

Species	Site	Habitat	TL	YL	ML	Fr	Se	Fl	B/B	L/F	O/U	Reference
Pygathrix												
cinerea	Kon Ka Kinh NP	Sub-tropical moist forest	58.9	49.5	9.3	41.0	-	-	-	-	0.1	This study
nigripes	Nui Chua NP	Tropical dry forest	54.6	-	-	19.8	9.6	14.6	-	-	1.5	Hoang Minh Duc 2007
nigripes	Seima Biodiversity Conservation Area (SBCA)	evergreen forest	39.9	-	-	11.4	39.7	8.8	-	-	0.2	Rawson 2009
nemaeus	Son Tra NR	Tropical lowland forest	82.0	-	-	14.0	-	4.0	-	-	-	Lippold 1998
nemaeus	Phong Nha	Tropical lowland forest	63.0	-	-	37.0	-	-	-	-	-	Pham Nhat 1993
nemaeus	Cuc Phuong	Semi-wild habitat	62.0	-	-	13.0	-	25.0	-	-	-	Otto 2005
nemaeus	Son Tra NR	Tropical lowland forest	87.8	68.6	31.4	10.2	-	1.6	0.4	-	-	Ulibarri 2013
nemaeus	Son Tra NR	Tropical lowland forest	65.5	-	-	17.8	2.0	5.3	-	-	9.4	Clayton 2018
Rhino-pithecus												

Table 9. continuation

avunculus	Tac Ke/Nam Trang	Tropical broadleaf forest	38.0	-	-	62.0	-	-	-	-	-	Boonratana & Le Xuan Canh 1998
avunculus	Khau Ca	Limestone broadleaf forest	53.1	46.2	6.9	25.0	7.2	12.2	-	-	2.4	Dong Thanh Hai 2008
roxellana	Qinling Mount	Deciduous broadleaf forest	24.0			29.4			15.3	29.0	1.0	Guo et al. 2007
bieti	Wuyapiya	Conifer forest	>6	-	-	-	-	-	-	86.0	8.0	Kirkpatrick et al. 1998
bieti	Tacheng, Yunan	Conifer forest/ broadleaf	31.0	-	-	-	-	-	-	60.0	-	Ding & Zhao 2004
bieti	Xiaochangdu, Tibet	Conifer forest	12.0	-	-	0.6	-	1.1	-	82.0	-	Zuo-Fu Xiang et al. 2007
brelichi	Fanjingshan	Temperate broadleaf forest	71.0	-	-	15.0	-	7.0	-	0.2	6.0	Bleisch et al. 1993
strykeri	Gaoligong Mountains	Sub-tropical evergreen broad-leaved vegetation	37.9	21.9	16.0	15.7	-	15.2	17.5	2.5	-	Yang et al. 2019
strykeri	Samumsam	Mangrove/ heath forest	41.0	-	-	41.0	15.0	3.0	-	-	-	Bennet & Sebastian 1988
Nasalis												
larvatus	Kinabatangan-Sukai	Peat swamp forest	74.0	73.0	<1	11.0	-	8.0	-	-	8.0	Boonratana 1993
larvatus	Tanjung Puting	Peat swamp forest	52.0	42.0	10.0	40.0	-	3.0	-	-	5.0	Yeager 1989
larvatus	Menanggul River	Riverbanks forest	66.0	66.0	-	26.0	-	-	-	-	-	Matsuda et al. 2009

TL: total leaves; YL: young leaves; ML: mature leaves; Fr: Fruit; Se: Seed; Fl: Flower; B/B: Bud and bark; L/F: Lichen and Fungi; O/U: Unidentified