Selectivity in feeding preferences and ranging patterns in spider monkeys *Ateles geoffroyi yucatanensis* of northeastern Yucatan peninsula, Mexico

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**Abstract** The spider monkey, a fruit specialist and important seed dispersal agent in the Neotropics, is an endangered primate due to habitat loss, hunting and the pet trade. Spider monkeys have been the subject of a few studies in Central and South America, but little is known about the diet and ranging for this primate in southern Mexico. Here we report the results of a six-month long study (October 2010 to March 2011) of the feeding preferences and ranging patterns of the Yucatan spider monkey *Ateles geoffroyi yucatanensis* living in the “Ya’ax’che” reserve by the Caribbean coast in northeast Yucatan peninsula. Focal animal and scan sampling as well as GPS tracking were used to document spider monkey feeding behavior, location of food trees and ranging in the reserve. The spider monkeys used 36 species of plants (94% trees; \(n=432\)) and six non tree morphospecies as a source of food. Six tree species accounted for ≥80% of total feeding time and for 74% of all trees used. Fruits accounted for 59% of total feeding time, followed by leaves (35%), palm piths (5%) and other plant parts (1%). Total range used by the monkeys was estimated at 43% of semievergreen rainforest habitat available (ca 40ha). Range use was not random with segments showing light, moderate and heavy use; the use of different areas of their range varied monthly and was closely linked to the spatial dispersion of the trees used for food [Current Zoology 59 (1): 125–134, 2013].

**Keywords** Primates, Frugivory, Neotropics, Conservation, Seed dispersal

Mexico harbors the northernmost distribution of non-human primates in the American continent, with two howler monkey species, the mantled howler monkey *Alouatta palliata mexicana*, and the black howler monkey *A. pigra*, and one spider monkey, represented by two subspecies *Ateles geoffroyi vellerosus* (the Mexican spider monkey) and *A. g. yucatanensis* (the Yucatan spider monkey) (Collins, 2008). Historically, *A. g. vellerosus* had a broad geographic distribution in Mexico, ranging from southern Tamaulipas and through northern Central America. The other subspecies, *A. g. yucatanensis*, is endemic to the Yucatan peninsula (Rylands et al., 2006) and it is classified as Endangered in the IUCN Red List (IUCN, 2012).

Habitat loss and fragmentation are important pressures upon the conservation of spider monkey populations throughout their distribution in the Neotropics (Di Fiore and Campbell, 2007). Spider monkeys are also among the most frequently hunted monkeys for their meat and for the pet trade (Duarte-Quiroga and Estrada, 2003; Rylands et al., 2006; Ramos-Fernández and Wallace, 2008). A long inter-birth interval in spider monkeys increases extinction risk by impeding rapid population recovery in areas of high hunting pressure, habitat loss, and habitat fragmentation (Strier, 2007; Ramos-Fernández and Wallace, 2008). Very little is known about the feeding preferences and ranging patterns of the Yucatan spider monkey, with only one study available to date in the Punta Laguna reserve (Ramos-Fernández and Ayala-Orozco, 2003).

Spider monkeys are fruit-eating specialists. A recent review of 10 studies in Mesoamerica reports that they consume fruit from a large number of plants (about 364 species of 76 families) and that 45% of these species contributed to 80% of total feeding time, suggesting a strong selectivity for a subset of the species used (González-Zamora et al., 2008). Studies of spider monkeys in several study sites also indicate that variation in fruit diet composition is closely related to the abundance of particular plant species (Russo et al., 2005; Di Fiore et
al., 2008) and that Ateles choose species with high energy contents (Stevenson and Link, 2010). In this paper we report the results of a six-month long study (October 2010 to March 2011) of food-plant preferences and ranging patterns in a population of A. g. yucatanensis existing in the “Yá’ax’che” reserve, in the northeast coastline of the Yucatan peninsula. We predicted that spider monkeys would be selective in the choice of food used and that a small number of these species would account for the bulk of their diet.

Due to their large body size and their preference for ripe fruits (a patchily distributed resource), spider monkeys are known for relatively wide ranging behavior, with home range sizes varying from 95 and 390 hectares in continuous forests and up to more than 900 hectares on Barro Colorado Island in Panama (Wallace, 2006, 2008). Other factors known to affect the ranging behavior of spider monkeys include the position of water resources, location of sleeping sites, climatic extremes, the need to patrol and defend boundary areas of the home range and variation in the perceived predation risk of differing habitats (Di Fiore and Campbell, 2007; Wallace, 2008; Asensio et al., 2011). Spider monkeys are reported to use core areas within their range that vary in size and location across seasons and years, suggesting the shifting use of food productive areas and monitoring of resources over time (Wallace, 2008; Asensio et al., 2011). In addition, it has been suggested that spider monkeys reduce feeding competition amongst individuals by adjusting subgroup size (Aureli and Schaffner, 2008). In our study we assumed that spider monkey use of available habitat would not be random and that range use patterns would be associated with the spatial dispersion of the trees used as a source of food.

1 Materials and Methods

1.1 Study site

The “Yá’ax’che” reserve (JB from here on), is a state government protected area found on the Caribbean coastline about 40km south of the city of Cancun in northeast Yucatan Peninsula, Mexico (20°50′43.72″ North and 86°54′00.76″ West, 15m altitude) (Fig. 1). The protected area was established in 1982 and it encompasses about 65 ha. About 60% of the protected area is semievergreen medium forest with trees no taller than 20 m. The rest of the reserve bordering the coast line is occupied by mangroves. The forest of the reserve is part of an intermittent strip of forest running south from the reserve parallel to the coastline for about 30km. The climate in the region is hot and humid. Mean annual precipitation is 1,265 mm, with a dry season between December and April (mean monthly rainfall 59 mm) and a wet season from May to November (mean monthly rainfall 138 mm). Mean annual temperature is 26°C. For several decades, both the rainforest and mangrove forest enjoyed local protection by the state government until the growth of tourism infrastructure along the Caribbean coastline led the government to delimit the land as a formal reserve in 1982. The historical and current protection of the reserve resulted in the conservation of a varied wildlife, including the spider monkeys. Until now no studies of the feeding preferences and range use have been carried out on the spider monkey population in the reserve.

1.2 Behavioral observations

All observations reported here were carried out by Carmen Scherbaum (CS from here on). Data on feeding preferences and ranging were collected on the spider monkey population monthly from October 2010 to March 2011.
An existing system of trails in the reserve allowed CS to follow spider monkey subgroups or solitary individuals closely. Because a segment of the reserve is open to the public, spider monkeys have become partially habituated to the presence of humans. Use of trees ranging in height from 3–15m by spider monkeys facilitated observations. Individuals were identified by their facial marks, size and anogenital traits. We defined a subgroup as individuals being within 30 m of any other community member (Slater et al., 2009). Spider monkey subgroups were followed daily from dawn to dusk (06:30-18:00 hrs). A minimum of 15 days of observations per month was completed. Each time a subgroup was encountered, it was followed for as long as possible. Information on subgroup size and composition was obtained only when the subgroup being followed was stationary. Instantaneous scans (maximum duration of 3 minutes) were used every 15 minutes and repeated counts of the number of individuals within sight were conducted. Individuals were classified as adults, juveniles, and infants based on their size and as males or females based on observation of their anogenital region.

1.3 Feeding behavior

Feeding behavior was recorded using focal animal sampling (Altmann, 1974). Individuals in the subgroup were observed for a period of 5 minutes each. After completing a 5 minute sample, CS switched to another individual within visual range. An effort was made to complete as many focal samples as possible from individuals in major age/sex classes (adults and juveniles and males and females) for the time the observer was able to stay with the subgroup. Total focal time accumulated for each major class in the group (Adult and juvenile females (n = 18) and adult males (n = 1) was proportional to their presence in the group, 95% and 5%, respectively.

When feeding behavior occurred, the plant life form was specified (tree, shrub, climber, epiphyte, other) and the plant part consumed was noted. Fruits consumed were classified as fleshy (berries, drupes), syconium, and other (e.g. achene, legume, nut). The posture assumed by the focal animal when feeding was recorded as suspensory, quadrupedal and sitting. Feeding heights recorded were estimated visually by CS after a period of training at the start of the study using a laser range finder to match estimates of heights ranging from 5 to 20m, until a 95% accuracy was achieved.

All trees used by the spider monkeys as a source of food were marked, measured (height and DBH) and geopositioned with a GPS (Garmin Oregon 450). Each tree species was identified with the aid of existing field guides to the trees of the JB reserve and with the aid of local indigenous Mayan field assistants. In addition to trees, other plant life forms were identified when possible and those that were not, were numbered consecutively (e.g. species 1 – n). Plant nomenclature followed the Missouri Botanical Garden nomenclatural update database (http://www.tropicos.org). Plant species which together contributed ≥70% of the total feeding time (TFT from here on) were considered as “top food resources” (González-Zamora et al., 2008; Chavez et al., 2011).

1.4 Total range estimate

Estimate of the area used by the spider monkeys during the study is not reported as a home range estimate, but rather as total range estimate for the duration of the sampling period (Laver and Kelly, 2008). Total range use by the spider monkeys was estimated by recording every 15 minutes the geoposition of the central mass of each spider monkey subgroup under observation. The GPS location data were transferred and plotted onto a gridded (0.25 ha cells; n = 160) digital map of the semievergreen medium forest in the reserve using Google Earth GIS utilities. The number of 0.25 ha cells entered by the spider monkey subgroups provided a general assessment of size of the range area they used during each month of the study period. Intensity of use of each 0.25ha cell was calculated after data collection by ranking the cells by the number of GPS records scored in each. A total of 2009 records were scored. Four cells accounted for >5% of the records (heavy use), 20 cells accounted for 1% to 4% (moderate use), and 46 cells accounted for <1% (light use). This classification was used to graph range use by the spider monkeys.

1.5 Ranging behavior

Day range was calculated by using the GPS data from consecutive readings recorded from day follows (Wallace, 2006). We defined day follows, as those sessions where we were able to follow the same subgroup for a minimum duration of five hours of consecutive GPS readings. These records were used to calculate an estimate of average day range for the months of the study period and an overall average. GPS points at a distance of ≤ 30 m from each other were considered as the same location and not included in the calculation of day journey length.

1.6 Vegetation survey

To estimate the relative dominance of tree species used by spider monkeys as a source of food in the tree community at the study site, we sampled the tree vege-
tation in the area of the reserve used by the spider monkeys using 10 randomly located 50 × 2 m transects (Gentry, 1988). This procedure is logistically simple to implement and it is a standard method used world-wide for sampling vegetation in tropical forests, as it allows for comparable units and the resulting data are an accurate statistical representation of the structure and composition of the vegetation of the surveyed area (Gentry, 1988; Chavez et al., 2011). Within each transect, we identified and measured all trees with a DBH of ≥ 10 cm and a height of ≥ 3 m. The vegetation transect data, extrapolated to 1.0 ha represented about 2.5% of the habitat area (semievergreen rainforest – 40 ha).

From the transect data we quantified species richness, density, and basal area for all tree species. For each tree species recorded in the vegetation survey we calculated an importance value index (IVI). The IVI is an indicator of the species importance in the vegetation and is calculated by the sum of the species density (number of individuals of species x / area sampled), frequency (number of transects in which species × occurs / total number of transects) and dominance (total basal area of the species in the sampled area) (Arroyo-Rodriguez et al., 2007; Chavez et al., 2011).

2 Results

During the six-month long study CS completed completed 1,597 scans aimed at counting individuals in spider monkey subgroups encountered, collected 2,004 records of the geoposition of subgroups under observation, accumulated 252 h of individual focal samples and geopositioned 432 trees used by the monkeys as a source of food. The average monthly percent of focal time across age/sex classes was: adult females 63% (± 6%), juveniles 33% (± 4%) and adult male 4% (± 2%). We completed 92 day follows of subgroups, but only considered those ranging in duration from 5.0 to 8.5 hours (n = 20) to estimate day range. These were spread out through each of the months of the study period.

2.1 Estimated size of the spider monkey population

Based on repeated counts of subgroups and on recognizable individuals, at the end of the study period we estimated the population of spider monkeys in the reserve to consist of a single community with 30 individuals: 13 adult females, 1 adult male, 5 juvenile females, 2 infants > 6 months of age (one male, one female) and 9 infants < 6 months old. The latter infants were born during the study period between November 2010 and February 2011. One adult female lost its infant during the study period, at the beginning of December 2011. Because of the short length of the study we cannot ascertain a seasonal pattern in births, but the birth of nine infants in a four month period may suggest such pattern. Average subgroup size was 6 ± 5 individuals with a range of 1–30. Subgroups consisted on average of 2.88 ± 1.97 adult females, 1.53 juvenile females, 1.84 ± 1.99 infants, and 0.23 ± 0.42 adult males.

2.2 Plant taxa used as sources of food

During the study period, spider monkeys used 36 species of plants (32 genera, 25 families) and six morphospecies as a source of food. Trees were represented by 34 species (432 individuals; 30 genera, 23 plant families). The six morphospecies were unidentified climbers (43 individuals). One species was a shrub and one an epiphyte (Table 1). Spider monkeys spent 97% of their feeding time feeding on trees and 3% feeding on climbers, shrubs and epiphytes (Table 1). The families that were most used as food sources were Sapotaceae, Moraceae and Nyctaginaceae, together representing ca 70% of TFT (Table 1). The average height of food trees used by the spider monkeys as a source of food was 9.63 ± 3.43 m (range 2 – 20 m; n = 432) and the average DBH was 24.05 ± 16.42 cm (range 2 – 142 cm; n = 381). The average height at which the spider monkeys fed was 8.84 ± 3.05 m (range 2 – 20 m). While food trees used by the spider monkeys were highly dispersed within their range, they were also aggregated in clusters (Fig. 2).

2.3 Feeding on fruits, leaves and other

The monkeys spent 59% of TFT feeding on fruits, 35% feeding on leaves, 5% feeding on palm piths and 1% feeding on buds, stems, unidentified plant parts, flowers, decayed wood and sap. Twenty-two tree species and five morphospecies were used as a source of fruit and 20 plant species and two morphospecies were used as a source of leaves by the spider monkeys (Table 1). Although 27 plant taxa were used as a source of fruit by the spider monkeys, only three of these accounted for ≥ 80% of TFT on fruit and can thus be classified as top resources for this type of plant part. The tree species Mastichodendrum foetidissimum and Manilkara zapota were the most important source of fruit. Together they accounted for 78% of TFT on fruit (Table 1). Four tree species contributed to ≥ 80% of TFT on leaves, with Brosimum alicastrum accounting for 65% of TFT on this plant part (Table 1). These preferred plant species accounted for 74% of the trees used as a source of food during the study period.
Table 1  Plant species used by the spider monkeys as food resources during the study period

| Family and species                  | % TFT  | Number of individuals used | Months used | Plant part | Plant life form | IVI  |
|-------------------------------------|--------|----------------------------|-------------|------------|----------------|------|
| *Mastichodendron foetidissimum* (Sapotaceae) | 25.38  | 39                         | 6           | fr, fur, ly, ba | t               | 1.64 |
| *Brosimum alicastrum* (Moraceae)    | 22.87  | 82                         | 6           | ly, lm     | t               | 0.59 |
| *Manilkara zapota* (Sapotaceae)     | 17.11  | 116                        | 6           | fur, ba    | t               | 3.11 |
| *Myrcianthes fragrans* (Myrtaceae)  | 5.58   | 18                         | 4           | fr, s      | t               | 0.25 |
| *Thrinax radiata* (Arecales)        | 5.53   | 52                         | 6           | fr, ph     | pt              |      |
| *Neea psychotrioides* (Nyctaginaceae) | 3.94   | 13                         | 6           | fr, ly, lm | t               | 0.60 |
| *Coccoloba diversifolia* (Polygonaceae) | 3.93   | 25                         | 5           | fr, ly, lm | t               | 0.95 |
| *Calyptranthes millsbaughii* (Myrtaceae) | 2.01   | 7                          | 3           | fr         | t               |      |
| *Ceiba pentandra* (Malvaceae)       | 1.98   | 10                         | 4           | ly, b      | t               |      |
| species 5                           | 1.45   | 16                         | 3           | fr         | cl              |      |
| species 1                           | 0.97   | 14                         | 3           | fr, ly, lm | cl              |      |
| *Acacia dolichostachya* (Fabaceae)  | 0.94   | 12                         | 5           | lm         | t               | 0.58 |
| *Malmea depressa* (Annonaceae)      | 0.89   | 11                         | 3           | fur, ly, lm| t               | 0.11 |
| species 6                           | 0.86   | 9                          | 3           | ly, lm, fl | cl              |      |
| *Maytenus guatemalensis* (Celastraceae) | 0.82   | 1                          | 1           | fr         | t               | 4.06 |
| *Cecropia peltata* (Urticaceae)     | 0.66   | 12                         | 5           | fr, ly, lm, st | t   |      |
| *Drypetes lateriflora* (Putranjivaceae) | 0.64   | 3                          | 3           | ly, lm     | t               | 0.71 |
| *Allophylus cominia* (Sapindaceae)  | 0.62   | 2                          | 2           | ly, b, fl  | t               |      |
| *Ficus sp.* (Moraceae)              | 0.58   | 2                          | 4           | fur, ly, lm | t               |      |
| species 3                           | 0.46   | 1                          | 1           | fur        | cl              |      |
| *Calyptranthes pallens* (Myrtaceae) | 0.4    | 1                          | 1           | ly         | t               |      |
| *Coccoloba cozumelensis* (Polygonaceae) | 0.39   | 1                          | 2           | fr         | t               |      |
| *Astronium graveolens* (Anacardiaceae) | 0.29   | 2                          | 1           | ly         | t               | 0.96 |
| *Guettarda combsii* (Rubiaceae)     | 0.27   | 4                          | 1           | fr         | t               | 0.11 |
| *Celtis iguanae* (Cannabaceae)      | 0.17   | 1                          | 1           | fr         | sh              |      |
| *Chlorophora tinctoria* (Moraceae)  | 0.14   | 1                          | 1           | lm         | t               |      |
| *Coccoloba reflexiflora* (Polygonaceae) | 0.14   | 1                          | 2           | fr         | t               |      |
| *Zanthoxylum caribaeum* (Rutaceae)  | 0.14   | 1                          | 1           | lm         | t               |      |
| *Cocconthrix readii* (Arecales)     | 0.10   | 2                          | 2           | fr         | pt              |      |
| *Vitex gaumeri* (Lamiaceae)         | 0.10   | 1                          | 1           | ly         | t               | 0.36 |
| *Parathesis cubana* (Primulaceae)   | 0.10   | 1                          | 1           | fr         | t               |      |
| *Piscidia piscipula* (Fabaceae)     | 0.09   | 2                          | 2           | ly, lm     | t               |      |
| *Coccoloba obtusifolia* (Polygonaceae) | 0.08   | 1                          | 1           | fr         | t               |      |
| *Casearia nitida* (Salicaceae)      | 0.08   | 4                          | 2           | ly         | t               |      |
| *Diospyros cuneata* (Ebenaceae)     | 0.06   | 1                          | 1           | fr         | t               |      |
| species 4                           | 0.06   | 1                          | 1           | fr         | cl              |      |
| *Carica papaya* (Caricaceae)        | 0.05   | 1                          | 1           | fur        | t               |      |
| *Cordia geranschanthus* (Boraginaceae) | 0.04   | 1                          | 1           | ly         | t               |      |
| *Bumelia obtusifolia* (Sapotaceae)  | 0.04   | 1                          | 2           | fur        | t               | 0.19 |
| species 2                           | 0.04   | 1                          | 3           | fr         | cl              |      |
| *Malpighia punicefolia* (Malpighiaceae) | 0.03   | 1                          | 1           | fr         | t               | 0.12 |
| *Anthurium schlechtendalii* (Arecales) | 0.01   | 1                          | 1           | lm         | e               |      |

TFT = total feeding time; Plant part: ly= young leaves, lm= mature leaves, fr= ripe fruit, fur= unripe fruit, ph= palm heart, fl= flower, b=bud, st= stem, ba= bark, s= sap and Plant life form: t= tree, pt= palm tree, cl= climber, sh= shrub and e= epiphyte. IVI=importance value index.
Fleshy fruits (berries and drupes) accounted for 99% of TFT on fruits which were harvested by the spider monkeys from 20 plant species (13 plant families) and five morphospecies. Syconia and akenes accounted for the remaining feeding time; each was harvested from one plant species respectively (syconia: *Ficus sp.*; akenes: *Cecropia peltata*). The postures displayed by the spider monkeys when feeding were suspensory (67%), sitting (31%) and quadrupedal (2%).

### 2.4 Monthly variations in use of food species

The top three tree species (*M. foetidissimum*, *B. alicastrum* and *M. zapota*) in the spider monkey diet were used in each month of the study period (Table 1). These species together accounted for 65% of TFT. Although not as high ranking in terms of TFT, tree species such as *Thrynax radiata* and *Neea psychotrioides* were also used in each month. The rest of the plant species (*n* = 31) in their diet were, on average, used for 2.13±1.31 months (Table 1). Sorensen’s index of similarity (0 no species shared – to 1 all species shared) between consecutive months ranged from 0.45 (Jan. – Feb.) to 0.81 (Nov. – Dec.); average 0.60. On average 60% of TFT per month was spent feeding on fruits, 33% on leaves and 7% on other items (palm hearts, flowers, buds, stems, bark, and sap). Although these values varied monthly for each plant part (Table 2), fruit was predominant in the diet, except for the month of February when fruits and leaves were equally important. Data also showed that the top three tree species in their diet (as indicated by TFT) were either first, second or third ranking in each of the six months of the study period, paralleled by the use of large number of trees of each of these species in each month (Table 3).

### 2.5 Total range estimate and day journey length

During the study period spider monkeys used 70 0.25 ha cells equivalent to 43% (17.5 ha) of rainforest habitat available within the reserve (ca 40 ha or 160 cells of 0.25 ha each). Area of habitat used varied from 5.5 ha in

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**Table 2** Monthly variation in percent of TFT on fruits, leaves and other plant parts (palm hearts, flowers, buds, stems, bark, and sap)

| Months (2010–2011) | Fruits [%] | Leaves [%] | Other [%] |
|--------------------|------------|------------|-----------|
| October            | 61         | 36         | 3         |
| November           | 59         | 36         | 5         |
| December           | 63         | 30         | 7         |
| January            | 73         | 15         | 12        |
| February           | 46         | 47         | 7         |
| March              | 56         | 38         | 5         |

**Table 3** Monthly dominant tree species in the spider monkey diet according to percent of TFT (total feeding time)

| Month  | Species 1  | No. of trees | % TFT | Species 2  | No. of trees | % TFT | Species 3  | No. of trees | % TFT |
|--------|------------|--------------|-------|------------|--------------|-------|------------|--------------|-------|
| Oct    | *B. alicastrum* | 27           | 20    | *M. fragrans* | 15           | 19    | *M. foetidissimum* | 15           | 13    |
| Nov    | *B. alicastrum* | 43           | 26    | *M. foetidissimum* | 11           | 25    | *C. diversifolia* | 12           | 10    |
| Dec    | *M. zapota*  | 45           | 26    | *M. foetidissimum* | 11           | 26    | *B. alicastrum*  | 28           | 22    |
| Jan    | *M. zapota*  | 25           | 36    | *M. foetidissimum* | 10           | 36    | *T. radiata*     | 11           | 13    |
| Feb    | *B. alicastrum* | 41           | 34    | *M. foetidissimum* | 17           | 29    | *M. zapota*     | 27           | 17    |
| Mar    | *M. foetidissimum* | 13           | 37    | *B. alicastrum*  | 12           | 14    | *M. zapota*     | 10           | 12    |

Also shown is the number of trees used of each by the spider monkeys.
March to 11.75 ha in December (Fig. 3). New 0.25 ha cells were added in each month and while others were not revisited, four 0.25 ha cells accounted for 41% of accumulated records ($n = 2,004$), 20 additional cells accounted for another 38% of the records and 44 cells accounted for the remaining 13% (Fig. 3). The difference between the expected and observed overall distribution of 0.25ha cell occupancy across the range was highly significant ($\chi^2 = 4271, df = 105, P = 0.001$), indicating that overall range use was not random. Average day journey length, calculated from a total of 20 day follows, was 674 m ± 282 m, range 412 m – 1,368 m.

### 2.6 Spatial dispersion of food trees and range use

Intensity of use of 0.25ha cells by the spider monkeys was closely associated with the number of food trees present in each cell ($r = 0.906, P<0.001$; if the outlier datum is removed, the strong correlation still holds ($r = 0.811, P<0.001$)) (Fig. 4). This suggests that range use by spider monkeys was strongly influenced by the spatial dispersion of trees of their preferred food species.

### 2.7 Vegetation survey

The vegetation survey recorded 184 trees representing 28 species of 17 plant families. Fifteen (44%) of the tree species used by the spider monkeys as a source of food appeared in the records. These included five of the six top tree species in the monkeys’ diet (Table 1). The average IVI value for the 15 species was 0.95 ±1.16 (range 0.11– 4.06) and that for the remaining 13 tree species - not recorded in their diet for the study period - was 0.52 ± 0.44. The average IVI value for the top five species in the spider monkey diet that appeared in the vegetation census was 1.19 ± 1.05.

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**Fig. 3** Map of the estimated total and monthly range of the spider monkeys for the study period
Cells are 0.25 ha and intensity of use is indicated by shaded pattern. From left to right, overall map for the six month-long sampling period (October 2010 to March 2011) and monthly maps.
3 Discussion

Our study showed that the number of plant species used as a source of food (n = 36) by the spider monkeys at the JB reserve was a small subset of the number of species estimated to be present at the study site (about 200, C. Elizondo pers. comm.). Such selectivity, also displayed at other study sites in the Neotropics where the diet of *Ateles* has been investigated, is suggested to be related to the abundance of the plant species used and to the high energy content of their fruits (Russo et al., 2005; Di Fiore et al., 2008; Stevenson and Link, 2010). The skewed distribution of the IVI value of tree species recorded in the vegetation census towards those species used by the spider monkeys as sources of food as well as that for the IVI value for the top five species in their diet, suggests that, in general, spider monkeys were using food species with a high relative importance in the forest. Some of the top food tree species (*B. alicastrum* and *M. zapota*) used by the spider monkeys at the JB reserve are also reported as among the top five species in the spider monkey diet at the inland site of Punta Laguna Reserve in northeast Yucatan peninsula (Ramos-Fernández and Ayala-Orozco, 2003) and at Tikal National Park, within the same general ecoregion (Cant, 1977).

Consistent with patterns observed in *Ateles* populations in Mesoamerica and South America (Di Fiore and Campbell, 2007; González-Zamora et al., 2008; Stevenson and Link, 2010) fruit was the principal food item in the diet of spider monkeys at the JB reserve, and a few fruit tree species were top ranking in their diet. Species such as *M. zapota* and *B. alicastrum* are known to be amongst the most important in the diet of spider monkeys in the Mesoamerican region (González-Zamora et al., 2008), including at the only other site in the Yucatan peninsula (Punta Laguna Reserve, about 100 km southwest of the JB reserve) where feeding preferences of spider monkeys have been studied (Ramos-Fernández and Ayala-Orozco, 2003). At the JB reserve, the highest ranking species in the fruit diet of spider monkeys during our study was *M. foetidissimum* (subspecies *gaumeri*; Sapotaceae), a tree species endemic to the Yucatan peninsula (Durán et al., 2000), but this species is not reported to be used at the Punta Lagunas reserve.

While fruit was a predominant food item in the diet of spider monkeys at the JB reserve, consumption of leaves also played an important part in their diet, accounting for 35% of TFT. In addition, fruit and leaf diet diversity were similar, 27 vs 22 species and morphospecies, stressing the value of leaves in the spider monkey diet. It has been pointed out that leaves seem to be a seasonally important food item for spider monkeys (Di Fiori et al., 2008) and our data showed that consumption of leaves was a consistent pattern from month to month in the spider monkeys at the JB reserve, with some months showing feeding times equivalent to those of fruit.

Day journey records in our study indicate that spider monkey traveled distances ranging from 0.4 km to 1.4 km, probably searching for trees of their preferred food species as suggested by the repeated presence of these in their monthly diet. Mean day journey length reported for spider monkeys at other sites in the Neotropics range from 0.46 km (*A. belzebuth chanek* in Bolivia) to 6.0 km (*A. belezbith chanek*, Cocha Cashu (Manu), Peru) (Wallace, 2008). At the Punta Lagunas reserve in the Yucatan, these records ranged from 1.18 km to 3.8 km (Ramos-Fernández and Ayala-Orozco, 2003).

Spider monkeys adapt to seasonal variation in fruit and leaf production by shifting areas within their range to find preferred food resources and by shifting food species in their diet (Wallace, 2006; Stevenson and Link, 2010; Ramos-Fernández et al., 2011), a pattern also apparent in the spider monkeys at the JB reserve. Our data showed that use of available habitat by the spider monkeys was not random; that their presence and activities were concentrated in specific sectors of their range and that such preference seemed to be associated with the spatial dispersion of their food trees, as suggested by the strong correlation found between these two variables.
Similar seasonal shifts in range patterns in association with the availability of food have been reported for *Ateles chamek* in northern Bolivia (Wallace, 2006). Range used by the spider monkeys during the study period was quite small compared to ranges reported for *Ateles* at other sites in Central and South America (95 ha to 390 ha in continuous forests; Wallace, 2006, 2008). At the site of Punta Lagunas, 100 km southwest of the JB reserve, the ranges of two spider monkeys communities, based on a four year sampling, were 95 ha and 166 ha, respectively. Because of the short length of our study, it is very likely that at other times of the year, spider monkeys at the JB reserve use other parts of the forest of the reserve, especially to the south and may also use the mangrove forest. Even though *Ateles* shows a preference for terra firme forests, it has also been reported to be temporarily present in mangrove forests (Eisenberg and Kuehn, 1966), as is the case with a spider monkey population inhabiting large areas of mangrove at Isla Concepcion, Chiapas, Mexico (Humberto Yee, pers. comm.).

To sum up, even though our study of feeding preferences and ranging of spider monkeys is limited to only encompassing six months of the annual cycle, it provides information that expands our knowledge of the feeding preferences and ranging by *A. g. yucatanensis* in the Yucatan peninsula. The study showed that spider monkeys at the JB reserve seem to have a food base consisting of a small subset of tree species from the forest. Within such subset, about six tree species seem to play an important role in their sustenance and their ranging seems to be associated with the spatial dispersion of their food trees.

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