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Ranging behavior of the southern yellow-cheeked gibbon (*Nomascus gabriellae*) in response to food resources and environmental variables

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Summary

Understanding animals' ranging behavior is critical for their management and conservation, especially for endangered and little-known species. In this study, one group of southern yellow-cheeked gibbons (*Nomascus gabriellae*), a highly threatened primate species distributed only in South Vietnam and Cambodia, was observed for one year in the lowland tropical rainforest of Cat Tien National Park in Vietnam. Data collection included the daily activities, the spatial location and movements of the group, and the location of food sources. The mean day range did not differ significantly between the dry season and the raining season (1.25 ± 0.41 vs. 1.21 ± 0.43 km), but differed significantly among different months and seasons; the longest daily travel distance was 2.43 km in November and the shortest distance was 0.30 km in May, the monthly average being 1.22 ± 0.42 km (mean ± SD). There was a significant difference in the seasonal use of the home range between the two seasons. Travelling time was lowest in the fruit scarce and foliage rich dry season compared to the rainy season. The daily mean temperature, fruit and leave consumption were among those biotic and abiotic factors that were significantly and positively correlated with the day range and home range use. We conclude that the ranging behavior of the gibbons varies seasonally in response to the weather condition and food resource availability in this lowland tropical rainforest.

Sự ảnh hưởng của nguồn thức ăn và yếu tố môi trường đến tập tính hoạt động của loài Vượn đen má vàng (*Nomascus gabriellae*)

Tóm tắt

Sự hiểu biết về những tập tính phạm vi hoạt động của động vật là rất quan trọng đối với việc quản lý và bảo tồn chúng, đặc biệt là đối với các loài có nguy cơ tuyệt chủng và ít được biết đến. Cả hai yếu tố phi sinh học (môi trường) và các yếu tố sinh học có thể đóng góp tạo nên tập tính phạm vi hoạt động của động vật; về sau, sự thay đổi của thời gian và không gian của nó, chỉ có thể là yếu tố quan trọng đối với những động vật có bộ não lớn, trong khi nghiên cứu về điều đó là khá thiếu. Trong nghiên cứu này, một gia đình Vượn đen má vàng (*Nomascus gabriellae*), một loài linh trưởng bị đe dọa cao chỉ phân bố ở phía Nam Việt Nam và Campuchia, đã được quan sát trong vòng một năm tại khu rừng mưa nhiệt đới đất thấp của Vườn Quốc gia Cát Tiên ở Việt Nam. Quan sát bao gồm toàn bộ hoạt động hàng ngày, vị trí không gian, di chuyển và vị trí của các nguồn thức ăn. Chúng tôi đã tìm thấy có sự khác nhau đáng kể trong việc sử dụng phạm vi hoạt động giữa các mùa khác nhau. Quãng đường di chuyển trung bình hàng ngày là không có sự khác biệt đáng kể giữa mùa khô và mùa mưa (1,25 ± 0,41 so với 1,21 ± 0,43 km), nhưng có khác biệt đáng kể giữa các tháng; khoảng cách di chuyển hàng ngày dài nhất là 2,43 km trong tháng 11 và khoảng cách ngắn nhất là 0,30 km trong tháng 5, trung bình hàng tháng là 1,22 ± 0,42 km. Có sự khác biệt đáng kể trong việc sử dụng vùng hoạt động giữa hai mùa; từ 0,29 km^2 trong mùa mưa đến 0,43 km^2 trong mùa khô và phạm vi vùng hoạt đông hàng năm là 0,45 km^2. Tương tự, tỷ lệ phần trăm thời gian được phân bổ cho các hoạt động khác nhau cũng thay đổi đáng kể qua các tháng. Nghỉ ngơi và các hoạt động xã hội cho thấy ít thay đổi hơn trong chu kỳ hàng năm so với hoạt động tìm kiếm thức ăn hoặc di chuyển. Thời gian sử dụng cho di chuyển thấp trong mùa có khan hiếm trái cây và nhiều lá non vào mùa mưa. Ngược lại, Vượn dành nhiều thời gian tìm kiếm thức ăn hơn trong mùa khô. Nhiệt độ trung bình hàng ngày, thời gian tiêu thụ trái cây và lá cây là một trong những yếu tố sinh học và phi sinh học có tương quan đáng kể và tích cực với quảng đường di chuyển hàng ngày và phạm vi hoạt động; 89,4% đối với biến nhiệt độ môi trường xung quanh và 44,4% biến thời gian tiêu thụ trái cây được giữ lại trong các mô hình tốt nhất cho chiều dài di chuyển hàng ngày, trong khi biến thời gian tiêu thụ lá cây 74,2% và biến thời gian tiêu thụ trái cây 44,8% được giữ lại trong các mô hình tốt nhất cho phạm vi hoạt động. Hơn nữa, hầu hết các điểm thay đổi hướng di chuyển hàng ngày (97,4%) có liên quan trực tiếp đến các hoạt động có ý nghĩa sinh học của chúng như kiếm ăn, di chuyển, điểm ngủ… Nghiên cứu của chúng tôi cho thấy rằng tập tính sử dụng phạm vi hoạt động của Vượn biến động rất lớn theo mùa, có lẽ là để thích nghi với tính thời vụ của nguồn thức ăn sẵn có và điều kiện thời tiết ở khu rừng mưa nhiệt đới vùng thấp này.

Introduction

The ranging patterns of arboreal frugivores, such as gibbons, are influenced by various ecological factors of their natural habitats; most of which are associated with the availability of food resources, daily activities and climate seasonality (Bartlett 2009; Coelho 1986; McConkey et al. 2003; Sarma & Kumar 2016). Diet often plays a critical role in determining home-range size regardless of taxonomic affinity (McNab 2002; McNeilage 2001; Robinson 1986). Fruit-eating species (frugivores) generally have large home-ranges (Robinson 1986), while leaf-eating species (folivores) inhabit smaller home-range areas (McNab 2002). For example, one of the folivorous gibbons, the siamang (*Symphalangus syndactylus*), has a smaller home range, shorter day range, and spends less time searching for food than other frugivorous gibbon species which have to invest more time travelling to scattered sites of fruit resources (Gittins & Raemaekers 1980; Palombit 1997).

Besides diet, several other factors may also affect the foraging strategies of social primates. Spatial and temporal patterns of resource availability, predation risk and navigation strategies have been found to affect animal foraging success (Bell 1990; Thums et al. 2011). A number of studies have examined the movement patterns of animal species to assess individual decision-making and potential travel-planning abilities using the change point test (CPT) and have revealed some of the mechanisms behind cognitive processes and foraging strategies (Asensio et al. 2011; Noser & Byrne 2014). For example, primates with larger cranial capacity and complex social systems are particularly good at planning their travel (Noser & Byrne 2014). Biologically relevant behavioral processes are more effectively detected along movement paths than in a random travel search (Noser & Byrne 2014; Schlägel & Lewis 2014; Suarez et al. 2014).

Maintaining energy balance is contingent upon food availability and the ability to exploit those food resources, which, in turn, is influenced by seasonal variation in climate (Stearns 1992). Numerous studies have documented seasonal variation in ranging patterns of primates associated with changes in the abundance, quality, or distribution of food resources (Di Fiore & Rodman 2001; Hanya 2004; Vasey 2005). Home range and diurnal activities also differ among primate populations of the same species living in different habitats. For example, the mountain gorilla (*Gorilla beringei*) was found to display different ranging patterns at different altitudes (Ganas & Robbins 2005; Nkurunungiet et al. 2004). Additionally, the eastern lowland gorilla (*G. b. graueri*), also showed differences in travel distance as well as variety of foods consumed between lowland forests and forests at higher altitudes (Yamagiwa & Mwanza 1994). Clearly, more studies are needed to better understand the ranging behavior and foraging strategies of different primate species.

The southern yellow-cheeked gibbon represents a species for which there is only limited data on its behavioral ecology and no previous study of its ranging behavior. This highly threatened and regionally endemic species is distributed to the east of the Mekong River and south of the Srepok River in Cambodia, and south of the Ba River and Srepok River in Vietnam and lives exclusively in undisturbed tropical forests and depends mostly on ripe fruits for food (Thanh et al. 2017). This gibbon species is currently categorized as endangered by the IUCN Red List (Rawson et al. 2020). It has been estimated that approximately 600 groups occur within protected areas in Vietnam (Hoang Minh Duc et al. 2015; Hoang Minh Duc et al. 2010; Rawson et al. 2011; Van Ngoc Thinh et al. 2009). At least 200 additional groups are estimated to occur in forest remnants outside protected areas (Hoang Minh Duc et al. 2015; Hoang Minh Duc et al. 2014). The Cat Tien National Park, the site for this study, is one of the strongholds for this species in Vietnam, with 149 groups recorded and an estimated density of 0.52 (±0.47) and 0.72 (± 0.08) groups per square kilometer for the two different sectors of the park, Cat Loc and Nam Cat Tien (Kenyon 2008).

Based on existing knowledge about primates' range behavior, we generated the following hypotheses that were tested in this study:

1) Since the southern yellow-cheeked gibbon is highly frugivore, while fruit resources in this seasonal forest varied among different seasons (Thanh et al. 2017), their range behavior should vary among seasons: a smaller home range in fruit-rich season and a larger home range in fruit-scarce season;

2) The directional changes (changing points) of the gibbon will be associated with food resources or the gibbons mainly travel from food tree to food tree (Noser & Byrne 2014).

Materials and methods

Study site

This study was carried out at Cat Tien National Park (CTNP; 11°20'-11°50'N, 107°09'-107°35'E). This 71,350 ha park was designated as a protected area in 1978 and was upgraded to a national park in 1992. It is managed by the central government's Ministry of Agriculture and Rural Development. CTNP consists of two separate sections, Cat Loc in the north and Cat Tien in the south (Fig. 1).

This study focused on the southern Cat Tien sector which is one of the last remaining evergreen and semi-evergreen rain forests in Vietnam (FIPI, 1993). Cat Tien also forms a transitional zone between two major ecosystems in Vietnam: 1) the southern end of the Dalat Plateau and 2) the Mekong Delta (Polet & Ling 2004). Our study site consisted mostly of tall (> 40 m) low-land evergreen and semi-evergreen forests (130-300 m asl), in which most of the canopy trees were deciduous

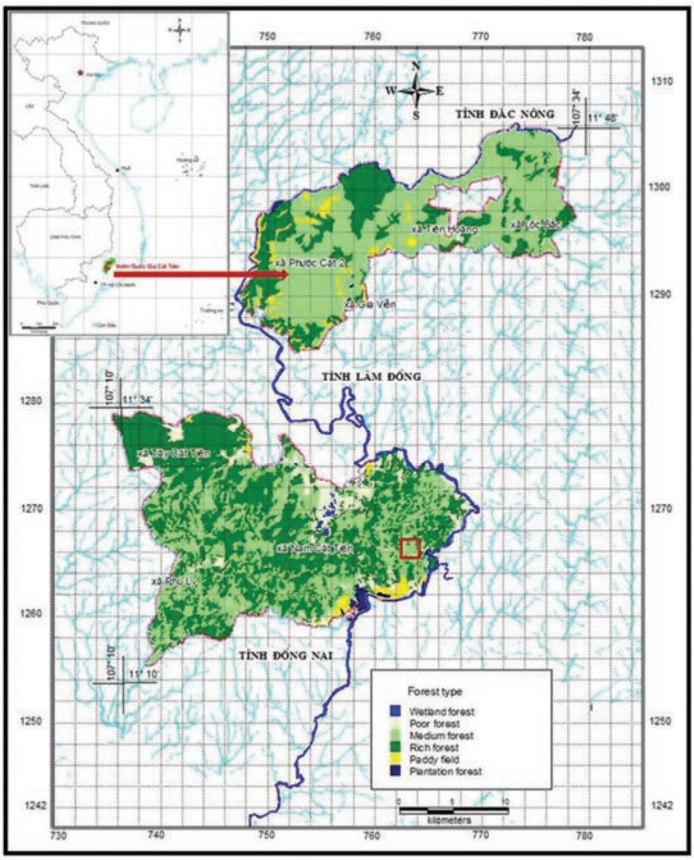

Fig.1. Location and study site of the studied gibbon group in Cat Tien National Park.

and most of the sub-canopy trees were evergreen (Fig. 2, 3). The climate is tropical with annual monsoon and there are two distinct seasons: a wet season from May to October, and a dry season from November to April (Fig. 4). The average annual temperature is 26.5° C and the average annual humidity is 82%. The monthly rainfall varies seasonally with most of the precipitation falling during the rainy season. The mean annual precipitation is 2200 mm.

Fig.2. Evergreen forest during the wet season. Photo: Bach Thanh Hai.

Fig.3. Semi-evergreen forest during the dry season. Photo: Bach Thanh Hai.

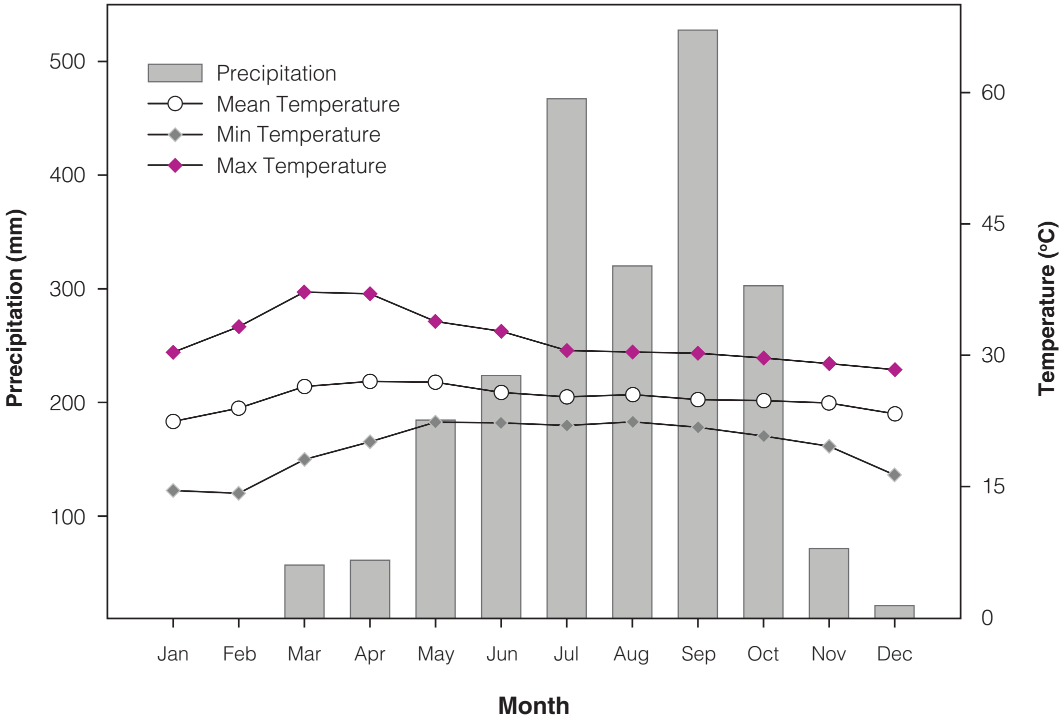

Fig.4. Monthly precipitation and temperature ranges at Cat Tien National Park, Vietnam, from November 2014 to September 2015.

Study group

For the purpose of this study, one family group of southern yellow-cheeked gibbons had been habituated to the observers for 6 months prior to the actual study period. This study group consisted of three individuals, one adult male, one adult female, and their single offspring were monitored from the moment the group left the sleeping site in the morning (approximately 5:30 am) to the moment they settled down at a sleeping site for the evening (approximately 6:00 pm) for 10-12 days per month for 12 consecutive months, from 1st October 2014 to 30th September 2015. We collected observations for a total of 1391 hrs during 168 days, including 124 complete and 44 incomplete days. For some days the observations were interrupted due to the intergroup fighting, heavy rain or disappearance of the group in dense vegetation. Whenever possible, the observers followed the gibbon family at a distance from 15 to 30 m and observed the behavior with binoculars. All field data were collected by BTH and two experienced field assistants.

Collection of behavioral data

The behavioral activities of the gibbons were recorded by scan sampling at 5 min intervals for 12–13 hours per day (Altmann 1974). A total of 79.900 scan samples were recorded. We recorded activities as resting, travelling, foraging, playing and other socializing and several specific activities as drinking, defecating and urinating. Resting included any inactive posture (sitting, lying, leaning, hanging and sleeping); travelling comprised movement (bipedal walking, quadrupedal climbing, brachiating, leaping, bridging and walking with occasional use of the arms). Foraging included searching, eating or swallowing food, whereas playing referred to grabbing, pulling, wrestling, manipulating other gibbon, chasing another gibbon, auto-playing, playing with branch or objects and moving through the trees with no obvious purpose like feeding or travelling. Other socializing included grooming, auto-grooming, calling (including solo, duet and alarm calls), conflict and fighting with other groups, mating, clinging to the mother and nursing the offspring. We also recorded the time and the location for each activity by each individual gibbon in order to calculate the total time invested on each activity.

Day range and home-range calculation

Movement data were collected at 5 min intervals by transcribing the movements of the observed family with reference to a detailed route map. We did not include incomplete days in the calculation of the daily travel length as the group might have travelled after we stopped observing. The day range were digitized and measured by MapInfo Professional 12.0 software and then visualized on the Google Earth Pro software (Fig. 5). We calculated home range size by combining all the observed travel routes using the minimum convex polygon method (Linnell et al. 2001). The outline of the minimum convex polygon was digitized in MapInfo Professional 12.0 software and then converted to areas to calculate the actual home-range size.

Fig.5. Example of daily movements recorded on 8th April 2015: blue pins represent observed gibbon locations at 5 minute intervals; red pins represent change points; F CP relevant to feeding, B CP relevant to branches; yellow line represents gibbons route.

Travel change-point detection

We applied the change-point test (CPT) (Byrne et al. 2009) in order to determine at which points the gibbons significantly changed their travel direction. The CPT examines routes composed of short linear segments (vectors) to detect points at which the direction of these vectors changes significantly, these are, 'change-points' in otherwise more uniform or undirected travel (Byrne et al. 2009). Accordingly, we applied the CPT to 124 daily travel paths of the complete observation days by calculating travel segments starting from the gibbons' last sleeping tree location of a given day until a change-point was discovered. This location then became the starting point for applying the CPT until the next change-point was found and so on, until no further change-points were detected for a daily path. We examined the activities observed at the change-points in order to assess whether the change-points reflect specific activities or activity patterns. In this study we used the data from instantaneous sampling at fixed intervals of 5 minutes, at variant level $q = 6$ and with an alpha level of $P < 0.01$ (for further details of level detection and detailed description of the CPT please see Byrne et al. (2009) and Asensio et al. (2011).

Data analysis

All statistical analyses were conducted in R studio 3.0 (R Core Team 2013). The amount of time dedicated to each activity was taken into a percentage to analyze diurnal and seasonal variation.

Kruskal-Wallis test was used to test the differences of time budgets between the hours of the day and between the months. The relationship between behavior activity (dependent variables) and ecological variables (independent variables) was tested using Pearson's partial correlation tests after visual inspection of residuals which indicated that assumptions for parametric statistics were not violated. When residuals did not fit the assumptions for parametric tests, we ran non-parametric Spearman rank correlations. Generalized Linear Models (GLM) with "BMA" package were run to simultaneously evaluate the possible influences of temperature, rainfall and diet on daily travel paths and home-range use concurrently. Code in R for performing the change-point test is available from http://www.mcs.st-andrews.ac.uk /wpej/CPT.html.

Results

Ranging pattern

During the 124 complete day observation periods, the study group travelled a total distance of 150 km. The mean daily travel distance was 1.22 ± 0.42 km; the longest daily travel distance was 2.43 km in November (dry season) and the shortest daily travel distance was 0.30 km in May (wet season). The mean daily distance did not differ significantly between the seasons (1.23 ± 0.42 vs. 1.21 ± 0.43 km), but the monthly mean travel length varied significantly (ANOVA; df = 11, 112; $F = 6.61$, $P < 0.001$) (Table 1).

Table 1. Monthly variation in mean day range and home range use.

Season/Months	Total day range (m)	Mean ± SD (m)	Home range (ha)
Rainy season	**67,861**	**1,212 ± 428**	**30.5**
May	8,523	947 ± 409	7.3
June	10,207	1,021 ± 279	8.3
July	14,455	1,446 ± 343	10.6
August	17,438	1,585 ± 392	13.2
September	8,887	1,270 ± 406	8.1
October	8,351	928 ± 195	11.1
Dry season	**82,512**	**1,232 ± 423**	**42.7**
November	15,102	1,079 ± 448	15.6
December	9,963	996 ± 185	15.8
January	15,304	1,177 ± 285	12.1
February	5,880	1,470 ± 272	19.4
March	16,861	1,405 ± 340	26.8
April	19,402	1,617 ± 403	18.4
Total	**150,373**	**1,223 ± 424**	**45.4**

The average home-range size was calculated to be 0.45 km^2. The home-range use varied monthly (Mann-Whitney Rank Sum Test N = 12, t =3.69, $P < 0.001$) (Table 1) and seasonally. The gibbons used the smallest daily home range in the rainy season (0.30 km^2) and largest daily home range in the dry season (0.43 km^2) (Fig. 6). The monthly home range was the largest in March (26.8 ha) and the smallest in May (7.3 ha).

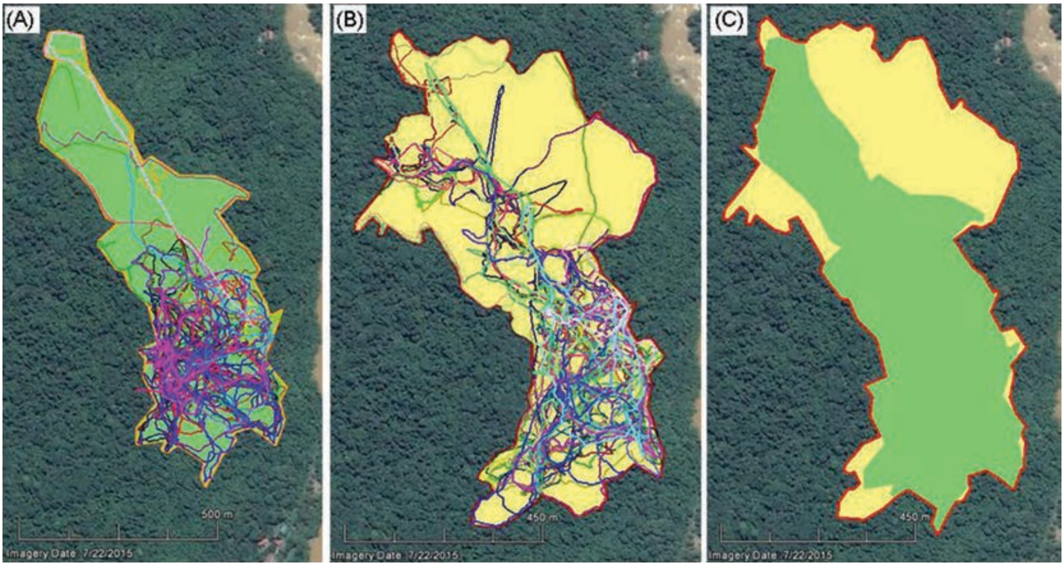

Fig.6. Day range and seasonal home range size of the female gibbon. A: wet season home range (green area) and daily travel tracks; B: dry season home range (yellow area) and daily travel tracks; C: superimposed home ranges for the dry and wet seasons (colored lines represent daily travel tracks for 124 days).

Travel change point

During the 124 days, when we were able to follow the gibbons the entire day, we detected a total of 351 travel change points (CP) (Appendix 1). Most CP (97.4 %) were directly associated with biologically meaningful gibbon activities. Only 2.6% CP were not associated with any behavior. A total of 182 (51.9%) CP were related to foraging; 85 (24.2%) related to travelling, such as encountering forest gaps; 77 (21.9%) of them involved resting activities such as resting, napping and sleeping places and 7 (2.0%) were connected with social activities such as duet calls, fighting and intergroup encounters. In most cases of foraging associated CPs (178 out of 182, 97.8%), the changes in the gibbons' travel direction coincided with food sources, of which 87 cases were fruit (48.9 %), 58 cases were leaves (32.6 %), 22 cases were flowers (12.3 %) and 11 cases were other food sources (6.2 %). There were significant differences between the categories of behavior associated with CPs (ANOVA; df = 3, 348; F = 37.8; $P < 0.001$). There were significant differences between the CPs related to foraging with travelling (Tukey test, q = 4.08, $P < 0.05$), foraging with resting (Tukey test, q = 4.25, $P < 0.05$) and foraging with socializing (Tukey test, q = 8.66, $P < 0.05$).

Relationship between daily activity budgets and ranging patterns

Over the course of the year, the study group spent 45% of their time foraging, 31.9% resting, 14.1% travelling and 9.0% on social activities. Daily travel distances were correlated significantly and positively with the travelling time budget, but were correlated negatively with the foraging time budget (Table 2).

Table 2. Spearman Rank correlation between percentage of time allocated to different daily activities and day range (N=124 days) and home range use (N=12 months).

Dependent	**Foraging**		**Traveling**		**Resting**		**Socializing**	
variable	*r*	*P*	*r*	*P*	*r*	*P*	*r*	*P*
Day range	-0.206	0.022 *	0.324	0.000**	-0.067	0.460	-0.016	0.863
Home range	0.699	0.010 **	0.685	0.013 *	0.035	0.904	-0.441	0.143

* Correlation is significant at $P \le 0.05$; ** Correlation is significant at $P \le 0.01$

The home range of gibbons was strongly influenced by foraging and time budget (Table 2). Results revealed that when the gibbon group spent more time on travelling, they also covered a greater distance; but when they spent more time on feeding, they had shorter daily travel distance.

Factors affecting ranging pattern

During the study period, we recorded a total of 69 plant species in 35 families consumed by gibbons. Fruits were the most common food item eaten (43.3%), followed by leaves (38.4%), flowers (11.6%) and other plant parts (buds, petioles, shoots, and roots) (6%). Insects and bird eggs contributed only 0.5% to the overall diet. The GLM analysis showed that the day range of the gibbons was affected by ambient temperature and the percentage of fruit and leaves in their diet (Fig. 7).

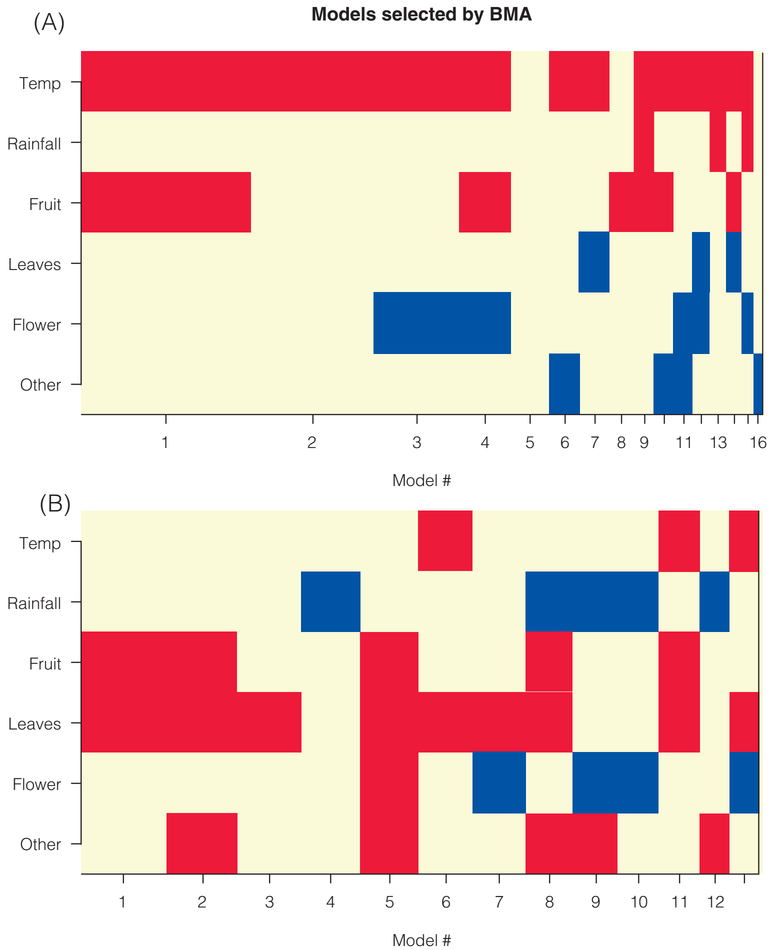

Fig.7. The influences of dietary, ambient temperature and precipitation on A: day range, and B: monthly home range of gibbons. Red color indicates positive influences and blue color indicates negative influences.

The day range of the gibbons was correlated strongly and positively with temperature and fruit availability; 89.4% of ambient temperature variable was retained in the best models and 44.4 % for fruit consumption variable. Further, home-range use was positively correlated with fruit and leaves consumption that retained 44.8% and 74.2%, respectively, in the best models (Table 3). Rainfall negatively affected monthly home-range use with 32.8 % frequency. Whereas leaves, fruits and other parts in their diet positively influenced home-range use with occurrence frequency in the best models were 74.2%, 44.8% and 37.1%, respectively.

Table 3. The three best models were selected by BMA for the influences of ambient temperature, rainfall and diet on day range (N = 124 days) and home range use (N = 12 months).

Dependent variable	Source	p!=0	SD	3 models were selected by BMA		
				model 1	model 2	model 3
Day range (m)	Intercept	100.0	744.79	-579.94	-471.48	-683.00
	Temperature	89.4	29.17	64.65	69.73	71.63
	Rainfall	7.0	1.03	-	-	-
	Fruit	44.4	3.76	6.76	-	5.70
	Leaves	9.0	1.19	-	-	-
	Flower	27.0	8.06	-	-16.51	-12.77
	Other	11.6	4.35	-	-	-
	nVar			2	2	3
	r^2			0.10	0.09	0.12
	BIC			-3.00	-1.64	-0.61
	post prob			0.25	0.13	0.08
Home range (ha)	Intercept	100.0	41.29	-23.27	-40.75	17.40
	Temperature	18.2	0.69	-	-	-
	Rainfall	32.8	0.011	-	-	-0.02
	Fruit	44.8	0.38	0.31	0.48	-
	Leaves	74.2	0.48	0.62	0.80	-
	Flower	33.4	0.28	-	-	-
	Other	37.1	0.52	-	0.60	-
	nVar			2	3	1
	r^2			0.52	0.60	0.37
	BIC			-3.80	-3.39	-3.03
	post prob			0.13	0.10	0.09

These results indicated that the gibbons travelled abundantly when they ate more fruit. In addition, the gibbons travelled longer distances during the warmer days than colder days. GLMs analyses also indicated that that the monthly home-range use of the gibbon group was affected by rainfall and the percentage of fruits and leaves in their diet (Fig. 4).

Discussion

Resource availability can affect diet, ranging patterns, and overall behavior of primates (Hemingway & Bynum 2005). The amount of time spent traveling and the distances travelled can vary according to the foraging strategy of the species (Nagy-Reis & Setz 2016). Seasonality in resource production also leads to the evolution of morphological, behavioral, and physiological adaptations in consumers (van Schaik et al. 1993) as they alter their foraging strategies according to temporal food fluctuations and adopt a low-cost/low-yield strategy (Nagy-Reis & Setz 2016). We designed this study to examine the ranging behavior of the southern yellow-cheeked gibbon at different seasons and various levels of the resource availability in a lowland tropical rainforest of Cat Tien National Park, Vietnam.

We acknowledge at the outset, that our study focused on a single group of gibbons. As such, we are limited in our ability to generalize the results to the entire population/species. We do believe however, at a time when primate biodiversity is in critical decline (Estrada et al. 2017), and there is a call to increase our study and understanding of a broader range of species (Bezanson & McNamara 2019), this study provides important and useful baseline data on a threaten species for which there is very limited information.

Our results demonstrate that for our study group of southern yellow-cheeked gibbons, their ranging behavior was strongly influences by the availability of food resources and daily activities, and was shaped by the seasonality of the climate. The daily travel distance of the gibbons varied considerably over the course of the year and the main influencing factors were the spatial distribution and abundance of preferred resources (fruits) as well as daily average temperature. The gibbons travelled more frequently and shorter distances when ripe fruit was abundant (rainy season), but less frequently and further when ripe fruit was scarce (dry season). This indicated that the gibbons spent more energy travelling but in return were able to obtain better food with high energy. A low density of fruit trees in their home range forces them to alter their diet pattern and switch to food sources of inferior quality such as young leaves, buds or shoots.

Shifting to lower-quality food also has been reported in the frugivorous white-handed gibbon (*Hylobates lar*) in Khao Yai National Park, Thailand (Bartlett 2009). The highly flexible feeding behavior of gibbons has often been discussed as they appear to eat whatever is available in their habitat. For example, the western black gibbon (*Nomascus concolor*) living in the highly seasonal habitat in Wuliang Mountain in Yunnan, China, is nearly entirely folivorous (Fan & Jiang 2008). Many primates adjust their ranging behavior in response to seasonal variation in food availability and distribution (Bartlett 2009; Di Bitetti 2001; Di Fiore 2003; Fan & Jiang 2008; Zhang et al. 2013). and this is more often the case for frugivorous primates than for folivorous primates (Glutton-Brock & Harvey 1977) because of the higher spatial and seasonal variance in the availability of fruit compared to leaves (Janson & Chapman 1999).

In our study, the gibbon group's travel routes were associated with biologically relevant activities and largely goal oriented, especially in finding preferred food resources. About half of all travel change-points were linked to feeding, particularly on fruit. Studies have shown that primates, including gibbons, have developed efficient strategies that allow them to discover and remember the locations of out-of-sight food resources (Noser & Byrne 2007). Two such strategies include an understanding of the reproductive phenology of preferred food plant species (i.e. temporal mechanism) and a better knowledge of resource organization and habitat structure (i.e. spatial mechanism). However, gibbons are more efficient than other primates in planning their travel because of their coordinated social organization, relatively small groups and overlapping home ranges (Bartlett 2009; Di Fiore & Suarez 2007; Savini et al. 2008). Though our results provide strong support that locating food resources was the decisive factor for the daily travel directions of the gibbons, the other travel change points may constitute locations where gibbons made critical decisions about where to travel next. Furthermore, these change points might constitute locations where gibbons deviated from their planned path due to constraints in the landscape (e.g. gaps in the canopy), where they escaped predation or where they encountered competing groups of gibbons (Asensio et al. 2011). This phenomenon is also well recognized in other primates like baboons (Noser & Byrne 2007).

The annual home-range use of the southern yellow-cheeked crested gibbon group was smaller than of other more folivorous *Nomascus* gibbons (45.5 ha vs. more than 150 ha reported for other species), and was more similar in size to the home range of *Hylobates* gibbons in less-seasonal forests (Table 2). The home ranges of frugivores usually tend to be bigger than those of folivores (Ruppell 2013), and they also often correlate with the body size of primates. The siamang (*Symphalangus syndactylus*) is to more than 50% folivorous and has a smaller home range than the frugivorous white-handed gibbon (Milton & May 1976), although it is twice the size of the white-handed gibbon. However, as noted above, we studied only one group of gibbons, and can therefore not evaluate the relationship between body size and home range use. The smaller home ranges of folivores have been attributed to the high availability of leaves compared to fruit. Fruit is usually widely dispersed and a less temporally predictable resource.

The southern yellow-cheeked gibbon is a frugivore, however their diet is flexible. They search for fruit and might travel long distances to locate them, but they rely on leaves and other items only during periods of low fruit availability. Hence, the availability of fruit appeared to be the main driver of their ranging ecology. A converse pattern of decreased ranging resulting in smaller home ranges during periods of abundant food availability has been observed in many other folivorous and frugivores primates such as sifaka (*Propithecus*)(Richard 1978), woolly spider monkey (*Brachyteles*) (de Carvalho et al. 2004), gorilla (*Gorilla*) (McNeilage 2001), colobine monkey (Colobinae) (Davies & Oates 1994), white-cheeked gibbon (*Nomascus leucogenys*) (Ruppell 2013) and eastern hoolock gibbon (*Hoolock leuconedys*)(Sarma & Kumar 2016). This consistency among species indicates that ranging patterns of primates are also an adaption to highly seasonal environments, in which small home ranges would pose a greater risk during times of extreme weather events and low food availability. Alternatively, larger home ranges could buffer them in case of extreme climate and food scarcity (Fan & Jiang 2008).

Gibbons and their habitat in Vietnam have faced continuous threats over the past ten years. Hunting for subsistence or larger international markets, habitat disturbance and forest fragmentation are the major threats to gibbons' survival. Resources for species conservation in the country are very limited. Our study provides essential information on the ecology of gibbons and will be helpful to develop urgently required conservation measures to safeguard the remaining populations of endangered gibbons from extinction. Conservation managers should consider the effects of food resource availability and habitat quality on gibbon ranging behavior when developing corridors, selecting sites for relocation or reintroduction programs, and designating and managing protected areas and primate rescue centers.

Authors' Contributions

BTH and JC designed the research and BTH conducted the field study. BTH, LK and AT analyzed the data and prepared the manuscript. All authors read and approved the final version of the manuscript.

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Appendix 1. Location and information of 351 change points were created by gibbons during 124 days following in Cat Tien National Park, 2015.

No	Change point's name	Date	Season	Time	Weather	Location (X,Y) UTM-WGS84	Activity
1	14	6, Jan	Dry	10:05	Sunny	764809, 1264372	Foraging
2	21	6, Jan	Dry	11:25	Sunny	764968, 1264328	Foraging
3	32	6, Jan	Dry	14:05	Sunny	764918, 1264687	Foraging
4	12	7, Jan	Dry	8:20	Sunny	764797, 1264824	Foraging
5	28	7, Jan	Dry	11:55	Sunny	764990, 1264580	Traveling
6	32	7, Jan	Dry	12:20	Sunny	764971, 1264540	Resting
7	34	7, Jan	Dry	12:35	Sunny	764903, 1264531	Traveling
8	40	7, Jan	Dry	14:20	Sunny	764891, 1264655	Traveling
9	12	8, Jan	Dry	7:50	Sunny	764926, 1264681	Resting
10	19	8, Jan	Dry	10:00	Sunny	764796, 1264625	Foraging
11	23	8, Jan	Dry	12:05	Sunny	764791, 1264716	Foraging
12	27	8, Jan	Dry	13:30	Sunny	764926, 1264682	Foraging
13	8	9, Jan	Dry	8:35	Sunny	764904, 1264691	Foraging
14	11	9, Jan	Dry	9:35	Sunny	764758, 1264664	Foraging
15	11	13, Jan	Dry	8:25	Sunny	765000, 1264281	Traveling
16	25	13, Jan	Dry	14:10	Sunny	764860, 1264467	Foraging
17	8	15, Jan	Dry	8:40	Sunny	764867, 1264663	Resting
18	15	15, Jan	Dry	11:05	Sunny	764990, 1264323	Foraging
19	14	20, Jan	Dry	8:25	Sunny	764557, 1264851	Foraging
20	20	20, Jan	Dry	11:20	Sunny	764625, 1264934	Foraging
21	17	21, Jan	Dry	12:10	Sunny	764712, 1264904	Resting
22	23	21, Jan	Dry	13:15	Sunny	764726, 1264790	Foraging
23	27	21, Jan	Dry	14:00	Sunny	764782, 1264807	Resting
24	11	22, Jan	Dry	11:15	Sunny	764783, 1264558	Foraging
25	17	22, Jan	Dry	12:10	Sunny	764855, 1264391	Foraging
26	9	27, Jan	Dry	11:25	Sunny	764907, 1264396	Foraging
27	15	27, Jan	Dry	13:40	Sunny	764924, 1264464	Resting
28	20	28, Jan	Dry	12:15	Sunny	764889, 1264729	Foraging
29	9	29, Jan	Dry	7:50	Sunny	764776, 1264604	Foraging
30	24	29, Jan	Dry	10:05	Sunny	764524, 1264987	Foraging
31	35	29, Jan	Dry	14:20	Sunny	764369, 1264945	Resting
32	9	3, Feb	Dry	10:45	Sunny	764520, 1264986	Resting
33	12	4, Feb	Dry	10:00	Sunny	764741, 1264306	Resting
34	22	4, Feb	Dry	14:00	Sunny	764723, 1264575	Traveling
35	16	5, Feb	Dry	10:45	Sunny	764710, 1264243	Foraging
36	24	5, Feb	Dry	13:15	Sunny	764778, 1264264	Traveling
37	32	5, Feb	Dry	14:10	Sunny	764830, 1264414	Foraging
38	8	5, Mar	Dry	7:30	Sunny	764971, 1264948	Traveling
39	12	5, Mar	Dry	7:50	Sunny	764797, 1264807	Foraging
40	21	5, Mar	Dry	13:50	Sunny	764880, 1264699	Traveling
41	8	6, Mar	Dry	7:05	Sunny	764933, 1264380	Traveling

42	11	6, Mar	Dry	7:30	Sunny	764742, 1264353	Traveling
43	23	6, Mar	Dry	10:35	Sunny	764749, 1264623	Foraging
44	29	6, Mar	Dry	15:10	Sunny	764783, 1264555	Resting
45	34	6, Mar	Dry	15:45	Sunny	764806, 1264777	Traveling
46	14	7, Mar	Dry	8:10	Sunny	764695, 1264255	Resting
47	26	7, Mar	Dry	10:30	Sunny	764770, 1264561	Resting
48	28	7, Mar	Dry	11:55	Sunny	764745, 1264619	Resting
49	33	7, Mar	Dry	13:05	Sunny	764771, 1264488	Foraging
50	39	7, Mar	Dry	14:45	Sunny	764902, 1264543	Foraging
51	10	12, Mar	Dry	8:20	Sunny	765005, 1264335	Traveling
52	23	12, Mar	Dry	11:45	Sunny	764688, 1264364	Foraging
53	29	12, Mar	Dry	13:35	Sunny	764719, 1264247	Foraging
54	38	12, Mar	Dry	15:45	Sunny	764755, 1264462	Resting
55	9	13, Mar	Dry	7:45	Sunny	764820, 1264719	Traveling
56	10	13, Mar	Dry	7:50	Sunny	764825, 1264671	Resting
57	14	14, Mar	Dry	8:25	Sunny	764666, 1264722	Traveling
58	21	14, Mar	Dry	10:30	Sunny	764997, 1264559	Foraging
59	25	14, Mar	Dry	14:05	Sunny	764964, 1264502	Traveling
60	11	19, Mar	Dry	9:15	Sunny	764759, 1264451	Foraging
61	20	19, Mar	Dry	13:25	Sunny	764816, 1264593	Resting
62	24	19, Mar	Dry	14:50	Sunny	764925, 1264551	Foraging
63	13	20, Mar	Dry	10:00	Sunny	764742, 1264426	Foraging
64	19	20, Mar	Dry	14:45	Sunny	764798, 1264511	Traveling
65	8	21, Mar	Dry	7:40	Sunny	764738, 1264543	Foraging
66	21	21, Mar	Dry	11:30	Sunny	764732, 1264344	Foraging
67	16	25, Mar	Dry	8:25	Sunny	764733, 1264243	Resting
68	12	26, Mar	Dry	7:10	Sunny	764671, 1264635	Foraging
69	18	26, Mar	Dry	9:00	Sunny	764729, 1264714	Resting
70	30	26, Mar	Dry	11:20	Sunny	764409, 1264996	Foraging
71	35	26, Mar	Dry	13:10	Sunny	764378, 1265064	Resting
72	38	26, Mar	Dry	13:30	Sunny	764413, 1265111	Traveling
73	42	26, Mar	Dry	13:50	Sunny	764458, 1265122	Foraging
74	48	26, Mar	Dry	14:50	Sunny	764485, 1265244	Foraging
75	50	26, Mar	Dry	15:00	Sunny	764545, 1265288	Resting
76	12	28, Mar	Dry	10:10	Sunny	764963, 1264509	Traveling
77	17	28, Mar	Dry	12:00	Sunny	764954, 1264409	Foraging
78	10	1, Apr	Dry	7:15	Sunny	764710, 1264313	Traveling
79	12	1, Apr	Dry	8:00	Sunny	764731, 1264236	Foraging
80	14	1, Apr	Dry	10:15	Sunny	764793, 1264416	Resting
81	16	1, Apr	Dry	10:30	Sunny	764771, 1264469	Foraging
82	18	1, Apr	Dry	10:40	Sunny	764778, 1264487	Resting
83	10	2, Apr	Dry	6:45	Sunny	764812, 1264471	Foraging
84	13	2, Apr	Dry	7:00	Sunny	764775, 1264466	Resting
85	20	2, Apr	Dry	7:45	Sunny	764843, 1264513	Foraging
86	30	2, Apr	Dry	8:50	Sunny	764819, 1264688	Resting

87	34	2, Apr	Dry	9:45	Sunny	764802, 1264769	Resting
88	43	2, Apr	Dry	13:00	Sunny	764905, 1264685	Foraging
89	49	2, Apr	Dry	14:35	Sunny	764863, 1264584	Traveling
90	55	2, Apr	Dry	15:15	Sunny	764958, 1264400	Foraging
91	8	4, Apr	Dry	9:15	Sunny	764723, 1264431	Foraging
92	20	4, Apr	Dry	13:25	Sunny	764738, 1264251	Foraging
93	9	8, Apr	Dry	6:40	Sunny	764734, 1264242	Foraging
94	14	8, Apr	Dry	7:15	Sunny	764800, 1264318	Foraging
95	17	8, Apr	Dry	7:30	Sunny	764851, 1264298	Foraging
96	23	8, Apr	Dry	8:00	Sunny	764885, 1264385	Foraging
97	30	8, Apr	Dry	8:55	Sunny	764984, 1264325	Foraging
98	35	8, Apr	Dry	10:05	Sunny	764969, 1264501	Traveling
99	42	8, Apr	Dry	11:30	Sunny	764856, 1264595	Foraging
100	59	8, Apr	Dry	14:30	Sunny	764628, 1264269	Foraging
101	8	9, Apr	Dry	7:50	Sunny	764670, 1264317	Traveling
102	33	9, Apr	Dry	11:25	Sunny	764850, 1264792	Foraging
103	43	9, Apr	Dry	13:00	Sunny	764504, 1264925	Traveling
104	47	9, Apr	Dry	13:45	Sunny	764488, 1265013	Traveling
105	52	9, Apr	Dry	14:10	Sunny	764461, 1264905	Foraging
106	9	10, Apr	Dry	8:55	Sunny	764473, 1264919	Traveling
107	14	10, Apr	Dry	9:30	Sunny	764606, 1264993	Foraging
108	27	10, Apr	Dry	14:30	Sunny	764781, 1264647	Traveling
109	8	11, Apr	Dry	6:40	Sunny	764735, 1264242	Foraging
110	12	11, Apr	Dry	7:20	Sunny	764599, 1264272	Foraging
111	19	11, Apr	Dry	8:00	Sunny	764748, 1264448	Resting
112	25	11, Apr	Dry	8:45	Sunny	764888, 1264399	Foraging
113	27	11, Apr	Dry	9:00	Sunny	764908, 1264431	Foraging
114	46	11, Apr	Dry	13:10	Sunny	764701, 1264813	Foraging
115	8	16, Apr	Dry	6:40	Sunny	764769, 1264724	Traveling
116	22	16, Apr	Dry	8:20	Sunny	764855, 1264386	Traveling
117	31	16, Apr	Dry	12:40	Sunny	764684, 1264185	Traveling
118	43	16, Apr	Dry	14:20	Sunny	764778, 1264427	Traveling
119	45	16, Apr	Dry	14:35	Sunny	764767, 1264465	Resting
120	8	17, Apr	Dry	7:00	Sunny	764768, 1264396	Foraging
121	18	17, Apr	Dry	8:55	Sunny	764711, 1264241	Foraging
122	26	17, Apr	Dry	14:15	Sunny	764870, 1264202	Traveling
123	33	17, Apr	Dry	15:05	Sunny	764927, 1264437	Foraging
124	21	22, Apr	Dry	8:05	Sunny	764603, 1264749	Foraging
125	45	22, Apr	Dry	13:10	Sunny	764774, 1264518	Resting
126	8	23, Apr	Dry	6:50	Sunny	764773, 1264492	Traveling
127	18	23, Apr	Dry	7:55	Sunny	764597, 1264167	Foraging
128	29	23, Apr	Dry	9:10	Sunny	764846, 1264403	Foraging
129	35	23, Apr	Dry	11:05	Sunny	764829, 1264520	Socializing
130	42	23, Apr	Dry	12:05	Sunny	764934, 1264619	Resting
131	56	23, Apr	Dry	14:55	Sunny	764720, 1264806	Traveling

132	16	24, Apr	Dry	7:45	Sunny	764942, 1264462	Traveling
133	21	24, Apr	Dry	9:40	Sunny	765009, 1264328	Foraging
134	28	24, Apr	Dry	11:30	Sunny	764752, 1264359	Traveling
135	31	24, Apr	Dry	12:30	Sunny	764697, 1264247	Foraging
136	8	6, Apr	Wet	6:50	Sunny	764813, 1264581	Foraging
137	23	6, Apr	Wet	10:00	Sunny	764719, 1264252	Foraging
138	10	7, May	Wet	6:25	Sunny	764694, 1264318	Traveling
139	13	7, May	Wet	6:50	Sunny	764736, 1264459	Foraging
140	20	7, May	Wet	7:45	Sunny	764968, 1264412	Foraging
141	25	7, May	Wet	8:45	Sunny	764968, 1264525	Foraging
142	33	7, May	Wet	11:00	Sunny	764823, 1264581	Traveling
143	8	12, May	Wet	9:40	Sunny	764744, 1264330	Traveling
144	16	12, May	Wet	10:30	Sunny	764874, 1264393	Foraging
145	19	12, May	Wet	11:25	Sunny	764981, 1264319	Foraging
146	12	13, May	Wet	9:00	Sunny	764808, 1264496	Foraging
147	17	13, May	Wet	9:45	Sunny	764737, 1264481	Foraging
148	23	13, May	Wet	10:25	Sunny	764710, 1264572	Traveling
149	31	13, May	Wet	13:10	Sunny	764996, 1264559	Foraging
150	11	14, May	Wet	7:30	Sunny	764749, 1264452	Foraging
151	8	21, May	Wet	7:05	Sunny	764744, 1264337	Foraging
152	11	21, May	Wet	7:30	Sunny	764764, 1264303	Foraging
153	25	21, May	Wet	10:10	Sunny	764863, 1264396	Foraging
154	28	21, May	Wet	11:10	Sunny	764969, 1264361	Traveling
155	41	29, May	Wet	13:30	light rain	764731, 1264264	Foraging
156	9	31, May	Wet	8:40	Sunny	764703, 1264429	Socializing
157	16	31, May	Wet	9:20	Sunny	764714, 1264323	Foraging
158	21	31, May	Wet	11:05	Sunny	764645, 1264236	Traveling
159	11	1, Jun	Wet	9:35	Sunny	764721, 1264235	Foraging
160	14	1, Jun	Wet	10:10	Sunny	764650, 1264239	Foraging
161	17	3, Jun	Wet	8:20	Sunny	764764, 1264397	Foraging
162	22	3, Jun	Wet	12:30	Sunny	764810, 1264483	Traveling
163	28	3, Jun	Wet	14:15	Sunny	764833, 1264400	Foraging
164	30	3, Jun	Wet	14:55	Sunny	764826, 1264366	Traveling
165	9	4, Jun	Wet	6:35	Sunny	764898, 1264489	Traveling
166	20	4, Jun	Wet	8:35	Sunny	764762, 1264459	Foraging
167	27	4, Jun	Wet	9:50	Sunny	764724, 1264364	Foraging
168	40	4, Jun	Wet	13:50	Sunny	764921, 1264622	Traveling
169	18	7, Jun	Wet	8:20	Sunny	764968, 1264338	Foraging
170	39	7, Jun	Wet	13:00	Sunny	764845, 1264572	Foraging
171	51	7, Jun	Wet	14:35	Sunny	764669, 1264583	Foraging
172	9	13, Jun	Wet	8:50	Sunny	764737, 1264342	Resting
173	22	13, Jun	Wet	11:40	Sunny	764906, 1264399	Foraging
174	30	13, Jun	Wet	14:45	Sunny	764991, 1264337	Traveling
175	10	14, Jun	Wet	6:30	Sunny	764704, 1264316	Resting
176	17	14, Jun	Wet	7:30	Sunny	764723, 1264462	Traveling

177	30	14, Jun	Wet	12:30	Sunny	764739, 1264234	Foraging
178	36	14, Jun	Wet	13:40	Sunny	764761, 1264341	Foraging
179	41	14, Jun	Wet	14:55	Sunny	764711, 1264373	Resting
180	29	22, Jun	Wet	13:00	Rain	764952, 1264369	Foraging
181	35	22, Jun	Wet	14:30	Rain	764875, 1264383	Traveling
182	12	24, Jun	Wet	9:35	Sunny	764944, 1264383	Foraging
183	20	24, Jun	Wet	12:40	Sunny	764965, 1264528	Resting
184	22	30, Jun	Wet	12:15	Sunny	764757, 1264454	Resting
185	26	30, Jun	Wet	13:05	Sunny	764730, 1264448	Traveling
186	32	30, Jun	Wet	13:55	Sunny	764817, 1264497	Foraging
187	35	30, Jun	Wet	13:40	Sunny	764910, 1264463	Traveling
188	13	1, Jul	Wet	6:50	Sunny	764741, 1264566	Resting
189	17	1, Jul	Wet	7:35	Sunny	764730, 1264507	Foraging
190	24	1, Jul	Wet	9:15	Sunny	764639, 1264693	Traveling
191	30	1, Jul	Wet	10:15	Sunny	764699, 1264611	Foraging
192	43	1, Jul	Wet	12:45	Sunny	764688, 1264399	Resting
193	50	1, Jul	Wet	14:00	Rain	764791, 1264433	Traveling
194	58	1, Jul	Wet	15:20	Rain	764956, 1264379	Traveling
195	10	2, Jul	Wet	8:45	Sunny	764809, 1264362	Traveling
196	19	2, Jul	Wet	11:20	Sunny	764801, 1264496	Foraging
197	11	6, Jul	Wet	7:35	Sunny	764876, 1264268	Traveling
198	15	6, Jul	Wet	8:35	Sunny	764994, 1264284	Traveling
199	33	6, Jul	Wet	10:55	light rain	764861, 1264458	Resting
200	41	6, Jul	Wet	11:45	light rain	764745, 1264465	Traveling
201	43	6, Jul	Wet	12:10	Cloudy	764725, 1264502	Resting
202	46	6, Jul	Wet	12:40	Cloudy	764702, 1264484	Traveling
203	52	6, Jul	Wet	14:05	Rain	764691, 1264544	Resting
204	8	14, Jul	Wet	6:45	Sunny	764829, 1264514	Traveling
205	26	14, Jul	Wet	10:00	light rain	764847, 1264199	Traveling
206	29	14, Jul	Wet	10:15	light rain	764808, 1264131	Foraging
207	44	14, Jul	Wet	12:40	Sunny	764891, 1264338	Traveling
208	46	14, Jul	Wet	12:50	Sunny	764949, 1264371	Foraging
209	11	15, Jul	Wet	8:30	Sunny	764800, 1264473	Foraging
210	18	15, Jul	Wet	9:30	Sunny	764833, 1264351	Foraging
211	24	15, Jul	Wet	10:15	Sunny	764970, 1264249	Traveling
212	12	21, Jul	Wet	9:05	Sunny	764912, 1264395	Resting
213	21	21, Jul	Wet	10:40	Sunny	764750, 1264324	Foraging
214	11	22, Jul	Wet	12:05	Sunny	764708, 1264669	Traveling
215	22	22, Jul	Wet	13:05	Sunny	764707, 1264470	Foraging
216	26	22, Jul	Wet	13:50	Sunny	764658, 1264458	Resting
217	9	23, Jul	Wet	7:00	Sunny	764705, 1264488	Foraging
218	16	23, Jul	Wet	8:55	Sunny	764737, 1264324	Traveling
219	25	23, Jul	Wet	10:05	Sunny	764714, 1264562	Foraging
220	29	23, Jul	Wet	10:45	Sunny	764810, 1264650	Resting
221	40	23, Jul	Wet	11:55	Sunny	764762, 1264464	Resting

222	51	23, Jul	Wet	13:10	Sunny	764706, 1264351	Resting
223	13	24, Jul	Wet	8:00	Sunny	764710, 1264484	Traveling
224	24	24, Jul	Wet	9:50	Sunny	764741, 1264311	Socializing
225	37	24, Jul	Wet	12:05	Sunny	764936, 1264388	Traveling
226	45	24, Jul	Wet	13:35	Sunny	764787, 1264434	Traveling
227	19	31, Jul	Wet	10:15	Sunny	764684, 1264419	Socializing
228	32	31, Jul	Wet	14:20	Sunny	764890, 1264663	Foraging
229	8	1, Aug	Wet	7:00	Sunny	764665, 1264454	Resting
230	16	1, Aug	Wet	8:15	Sunny	764686, 1264281	Socializing
231	24	1, Aug	Wet	9:00	Sunny	764792, 1264195	Foraging
232	26	1, Aug	Wet	9:10	Sunny	764824, 1264186	Foraging
233	36	1, Aug	Wet	10:25	Sunny	764743, 1264356	Resting
234	39	1, Aug	Wet	10:40	Sunny	764707, 1264363	Traveling
235	51	1, Aug	Wet	12:45	Sunny	764718, 1264572	Foraging
236	14	8, Aug	Wet	9:50	Rain	764699, 1264698	Foraging
237	24	8, Aug	Wet	11:30	Rain	764913, 1264601	Foraging
238	11	10, Aug	Wet	7:00	Cloudy	764762, 1264333	Resting
239	18	10, Aug	Wet	7:45	Sunny	764706, 1264391	Traveling
240	24	10, Aug	Wet	8:15	Sunny	764757, 1264468	Resting
241	30	10, Aug	Wet	9:10	Sunny	764812, 1264427	Traveling
242	48	10, Aug	Wet	10:50	Sunny	764632, 1264690	Foraging
243	8	16, Aug	Wet	6:10	Sunny	764719, 1264599	Foraging
244	37	16, Aug	Wet	9:50	Sunny	764721, 1264234	Resting
245	46	16, Aug	Wet	10:50	Sunny	764981, 1264277	Foraging
246	59	16, Aug	Wet	12:30	Sunny	764823, 1264411	Resting
247	61	16, Aug	Wet	12:50	Sunny	764765, 1264396	Foraging
248	9	19, Aug	Wet	6:25	Sunny	764701, 1264597	Foraging
249	11	19, Aug	Wet	7:00	Sunny	764724, 1264624	Foraging
250	17	19, Aug	Wet	8:25	Sunny	764663, 1264610	Traveling
251	28	19, Aug	Wet	12:10	Sunny	764897, 1264396	Foraging
252	11	20, Aug	Wet	7:30	Sunny	764694, 1264604	Resting
253	16	20, Aug	Wet	8:30	Sunny	764708, 1264516	Foraging
254	21	20, Aug	Wet	9:35	Sunny	764657, 1264458	Traveling
255	33	20, Aug	Wet	11:25	Sunny	764707, 1264591	Traveling
256	44	20, Aug	Wet	13:55	Sunny	764892, 1264693	Foraging
257	52	20, Aug	Wet	14:45	Sunny	764799, 1264547	Foraging
258	13	21, Aug	Wet	7:40	Sunny	764633, 1264684	Resting
259	25	21, Aug	Wet	10:10	Sunny	764772, 1264635	Resting
260	29	21, Aug	Wet	10:55	Sunny	764750, 1264683	Foraging
261	45	21, Aug	Wet	13:45	Sunny	764746, 1264329	Traveling
262	50	21, Aug	Wet	14:20	Sunny	764912, 1264284	Foraging
263	14	22, Aug	Wet	7:50	Sunny	764687, 1264799	Socializing
264	25	22, Aug	Wet	9:50	Sunny	764790, 1264540	Resting
265	38	22, Aug	Wet	12:05	Sunny	764726, 1264363	Socializing
266	8	29, Aug	Wet	7:05	Sunny	764761, 1264555	Resting

267	10	29, Aug	Wet	7:15	Sunny	764793, 1264570	Traveling
268	13	29, Aug	Wet	7:30	Sunny	764799, 1264528	Traveling
269	23	29, Aug	Wet	9:30	Sunny	764702, 1264589	Resting
270	34	29, Aug	Wet	11:00	Sunny	764776, 1264717	Resting
271	28	31, Aug	Wet	11:30	Sunny	764978, 1264387	Foraging
272	31	31, Aug	Wet	11:45	Sunny	764994, 1264284	Foraging
273	10	5, Sep	Wet	9:20	Sunny	764903, 1264640	Foraging
274	16	5, Sep	Wet	10:30	Sunny	764753, 1264465	Foraging
275	23	5, Sep	Wet	13:10	Sunny	764931, 1264392	Foraging
276	12	6, Sep	Wet	8:25	Sunny	764730, 1264427	Foraging
277	19	6, Sep	Wet	10:00	Sunny	764884, 1264386	Resting
278	11	7, Sep	Wet	7:45	Sunny	764729, 1264506	Foraging
279	18	7, Sep	Wet	10:25	Sunny	764762, 1264680	Foraging
280	22	7, Sep	Wet	11:15	Sunny	764900, 1264628	Foraging
281	11	13, Sep	Wet	8:10	Sunny	764750, 1264342	Foraging
282	15	13, Sep	Wet	10:00	Sunny	764713, 1264576	Foraging
283	8	16, Sep	Wet	7:10	Sunny	764973, 1264386	Foraging
284	12	16, Sep	Wet	9:05	Sunny	764942, 1264364	Resting
285	11	30, Sep	Wet	9:20	Sunny	764970, 1264341	Traveling
286	20	9, Oct	Wet	10:55	Sunny	764906, 1264673	Traveling
287	23	9, Oct	Wet	11:30	Sunny	764940, 1264669	Foraging
288	27	9, Oct	Wet	12:20	Sunny	764871, 1264738	Resting
289	13	10, Oct	Wet	8:00	Sunny	764854, 1264895	Traveling
290	8	17, Oct	Wet	7:35	Sunny	764959, 1264543	Resting
291	16	17, Oct	Wet	9:55	Sunny	764904, 1264288	Foraging
292	26	17, Oct	Wet	13:20	Sunny	764712, 1264348	Foraging
293	21	18, Oct	Wet	12:25	Sunny	764921, 1264624	Traveling
294	26	18, Oct	Wet	13:45	Sunny	764937, 1264532	Foraging
295	7	19, Oct	Wet	7:50	Sunny	764901, 1264555	Foraging
296	10	26, Oct	Wet	7:55	Sunny	764977, 1264351	Resting
297	13	26, Oct	Wet	8:50	Sunny	764939, 1264313	Foraging
298	22	26, Oct	Wet	11:05	Sunny	764806, 1264382	Resting
299	27	26, Oct	Wet	12:25	Sunny	764723, 1264340	Foraging
300	11	27, Oct	Wet	8:30	Sunny	764914, 1264571	Foraging
301	23	27, Oct	Wet	12:00	Sunny	764622, 1264899	Resting
302	13	28, Oct	Wet	11:30	Sunny	764391, 1265023	Resting
303	10	30, Oct	Wet	10:25	Sunny	764416, 1265266	Resting
304	17	30, Oct	Wet	12:00	Sunny	764402,1265210	Foraging
305	22	30, Oct	Wet	13:10	Sunny	764470, 1265192	Traveling
306	8	4, Nov	Dry	7:50	Sunny	764726, 1264707	Foraging
307	11	5, Nov	Dry	9:25	Sunny	764486, 1265076	Resting
308	16	5, Nov	Dry	12:45	Sunny	764465, 1265198	Resting
309	9	6, Nov	Dry	8:25	Sunny	764419, 1265301	Foraging
310	17	6, Nov	Dry	11:15	Sunny	764419, 1265207	Resting
311	22	6, Nov	Dry	12:30	Sunny	764539, 1265108	Foraging

312	26	6, Nov	Dry	13:05	Sunny	764480, 1265025	Resting
313	16	7, Nov	Dry	9:10	Sunny	764967, 1264526	Foraging
314	21	7, Nov	Dry	10:30	Sunny	764756, 1264393	Resting
315	23	7, Nov	Dry	11:35	Sunny	764700, 1264419	Resting
316	8	11, Nov	Dry	7:00	Sunny	764884, 1264388	Foraging
317	12	11, Nov	Dry	7:55	Sunny	764968, 1264350	Resting
318	24	11, Nov	Dry	11:10	Sunny	764799, 1264270	Foraging
319	28	11, Nov	Dry	12:55	Sunny	764753, 1264317	Resting
320	8	12, Nov	Dry	7:30	Sunny	764866, 1264560	Foraging
321	16	12, Nov	Dry	8:55	Sunny	764954, 1264367	Traveling
322	20	12, Nov	Dry	11:35	Sunny	764903, 1264373	Foraging
323	8	13, Nov	Dry	8:35	Sunny	764965, 1264372	Foraging
324	18	13, Nov	Dry	10:55	Sunny	764692, 1264374	Traveling
325	8	14, Nov	Dry	7:35	Sunny	764840, 1264481	Foraging
326	10	14, Nov	Dry	8:25	Sunny	764875, 1264562	Foraging
327	13	14, Nov	Dry	8:45	Sunny	764950, 1264547	Foraging
328	8	19, Nov	Dry	7:25	Sunny	764939, 1264570	Traveling
329	26	19, Nov	Dry	11:40	Sunny	764741, 1264787	Foraging
330	9	20, Nov	Dry	8:40	Sunny	764936, 1264379	Foraging
331	16	20, Nov	Dry	10:35	Sunny	764774, 1264400	Foraging
332	16	22, Nov	Dry	12:10	Sunny	764858, 1264590	Resting
333	8	25, Nov	Dry	9:35	Sunny	764436, 1265277	Foraging
334	15	25, Nov	Dry	12:05	Sunny	764645, 1265260	Foraging
335	16	27, Nov	Dry	9:10	Sunny	764964, 1264541	Foraging
336	13	28, Nov	Dry	8:55	Sunny	764840, 1264263	Foraging
337	16	28, Nov	Dry	10:00	Sunny	764896, 1264274	Foraging
338	23	28, Nov	Dry	11:15	Sunny	764869, 1264332	Foraging
339	12	1, Dec	Dry	10:50	Sunny	764433, 1264979	Foraging
340	16	1, Dec	Dry	12:25	Sunny	764384, 1265053	Foraging
341	9	7, Dec	Dry	10:00	Sunny	764939, 1264675	Foraging
342	11	9, Dec	Dry	12:05	Sunny	764532, 1265013	Foraging
343	18	15, Dec	Dry	13:40	Sunny	764882, 1264875	Resting
344	8	17, Dec	Dry	10:00	Sunny	764717, 1264810	Foraging
345	9	21, Dec	Dry	8:20	Sunny	764580, 1265002	Foraging
346	17	21, Dec	Dry	13:05	Sunny	764391, 1265010	Foraging
347	8	22, Dec	Dry	8:30	Sunny	764540, 1264964	Resting
348	16	22, Dec	Dry	11:05	Sunny	764372, 1265012	Foraging
349	12	23, Dec	Dry	8:55	Sunny	764638, 1264816	Traveling
350	11	24, Dec	Dry	11:10	Sunny	764554, 1264726	Foraging
351	14	24, Dec	Dry	11:35	Sunny	764701, 1264720	Foraging