

## Activity budget and behavioural patterns of free-ranging yellow-tailed woolly monkeys *Oreonax flavicauda* (Mammalia: Primates), at La Esperanza, northeastern Peru

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### Abstract

The critically endangered yellow-tailed woolly monkey (*Oreonax flavicauda*) is endemic to the cloud forests of north-eastern Peru and one of the least studied of all primate species. We conducted fifteen months of group follows using focal animal sampling techniques to gather the first behavioural data on free ranging *O. flavicauda*. Group follows took place in an area of disturbed primary and regenerating secondary forest near the village of La Esperanza, Amazonas department. Yellow-tailed woolly monkey activity budgets at La Esperanza average: 29.8% feeding, 26.3% resting, 29.0% travelling, 2.3% in social and 12.8% in other activities. Significant differences were observed in the frequency of behaviours between age/sex classes as well as on temporal scales. Our findings are similar to those of other woolly monkey species although yellow-tailed woolly monkeys were found to be more vocally active than other species. We recommend further study of this species at other sites with different forest types to better understand its behavioural ecology and conservation needs. Particular emphasis should be given to studying this species at different altitudes.

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### Introduction

Peruvian yellow-tailed woolly monkeys, *Oreonax flavicauda* von Humboldt, 1812, are large bodied diurnal

primates endemic to Peru (Leo Luna, 1980; Shanee, 2011). They are similar in size and social organization to common woolly monkeys (genus *Lagothrix*), and like other woolly monkeys they live in large multi-male multi-female social groups of up to 23 individuals (Shanee and Shanee, unpublished data). Other woolly monkey species are mainly found in lowland Amazonian rainforest (Fooden, 1963; Groves, 2001; Di Fiore and Campbell, 2010), although *Lagothrix lagothricha lugens* Elliot, 1907 has been observed as high as 3000 meters above sea level (Hernandez-Camacho and Cooper, 1975). *Oreonax flavicauda* is endemic to high elevation forests between 1500 and 2700 m.a.s.l. (Shanee, 2011), and is not found in lowland rainforest sites (Leo Luna, 1980).

*Oreonax flavicauda* is one of the least studied and most endangered of all primates. It is listed on Appendix I of CITES (2005) and as Critically Endangered (CR; IUCN category A4c) on the IUCN Red List of Threatened Species. *Oreonax flavicauda* is also listed as one of the 'World's 25 Most Endangered Primate Species' by the International Primatological Society (Cornejo *et al.*, 2009). Until recently *O. flavicauda* had been the focus of few studies (Leo Luna, 1980, 1982; Shanee *et al.*, 2007; Shanee, 2011; Shanee and Shanee, 2011) mainly because of its rarity and the physical and socio-political difficulties of working in the area to which it is endemic (Shanee, 2011). The only previous long term study of the species recorded basic ecological data (Leo Luna, 1982, 1987). Other published information on this species has been limited to sightings and conservation recommendations (Graves and O'Neil, 1980; Parker and Barkley, 1981; Rios and Ponce del Prado, 1983; Shanee *et al.*, 2007, 2008). As with other woolly monkey species (Botero *et al.*, 2010), *O. flavicauda* is the subject of a taxonomic dispute (Matthews and Rosenberger, 2008). For consistency we follow the taxonomy put forward by Groves (2001) as recommended by the IUCN primate specialist group.

While behavioural studies have been published on most species of common woolly monkeys (Di Fiore and Campbell, 2010), as yet no study has been published on the behavioural patterns or activity budgets of *O. flavicauda*. Only two previous studies have been made on this species' behaviour. One study on wild individuals in the Rio Abiseo national park (Villavicencio Cruz and Villalobos Gonzales, 1991) and another on a captive individual kept by the Natural History Museum of San Marcos University in Lima, Peru (Macedo Ruiz and Mittermeier, 1979).

We conducted follows on previously habituated groups of *O. flavicauda*. Data collection took place in an area of disturbed primary forest in the Comunidad Campesina de Yambrasbamba, Amazonas department. We collected behavioural data and activity budgets for three groups. This work was carried out in conjunction with a larger conservation effort aimed at the conservation of forests and endangered species in the area (Shanee and Shanee, 2009).

## Material and methods

### Study site

The Comunidad Campesina de Yambrasbamba study area lies on the eastern slopes of the Andes in North-eastern Peru. The area, known locally as *Peroles* (S 05°39'46", W 77°54'32"), encompasses approximately 1000 hectares of disturbed primary forest and regenerating secondary forest interspersed with pasture. The study site is bounded to the south, east and west by pasture and agricultural lands and to the north it is contiguous with extensive forest reaching to the Río Marañon (approximately 100 km). The site was chosen because of its location in a natural forest corridor between four protected areas where the species' presence has been recorded: Santuario Nacional Cordillera Colan, Bosque de Protección Alto Mayo, Zona Reservada Rio Nieva and the Area de Conservación Privada Abra Patricia-Alta Nieva (Fig. 1). The area is located about 5 km north of the village of La Esperanza, and lies between 1800 and 2400 m.a.s.l. Average monthly rainfall is approximately 1500 mm with a dry season from August to December. Average temperature for the area is 14°C ( $\pm$  5.7). Humidity is high year round.

The terrain is very rugged with high ridges and deep valleys, while the habitat in the area is characterised by *Ficus* spp. dominated primary pre-montane and montane cloud forest with an average canopy height of

15-25 m, including occasional emergent trees of up to 35 meters and a thick mid- and under-story.

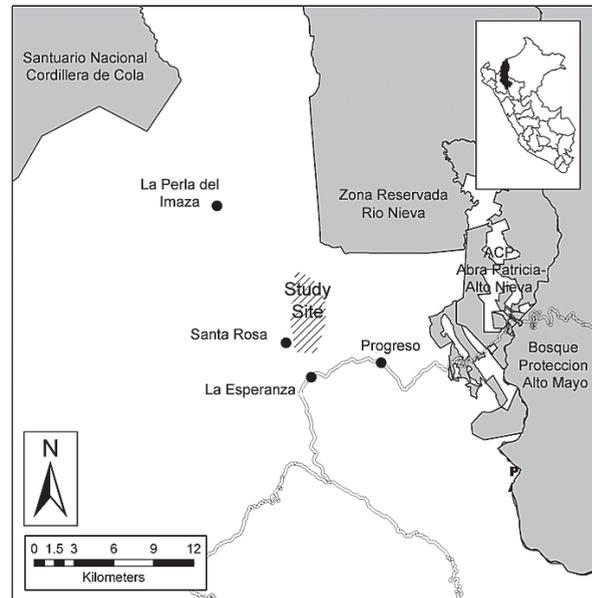


Fig. 1. Location of study site, showing outlying protected areas.

### Survey design

Data were collected on three groups of *O. flavicauda* using focal animal sampling (Altmann, 1974). We alternated between two field camps, each camp with one home group and one intermediate group with territory overlapping the two camps. All the groups in the study area were at least partially habituated to the presence of humans through contact with our researchers during previous field work. Habituation to the presence of humans had also occurred over previous years when small scale commercial logging took place; also the area is interspersed with pastures and plantations with farmers regularly passing through the forest on the way to their lands. Hunting had not occurred in the area for at least 5 years prior to the start of field work. Group follows were carried out by two pairs of trained observers each comprising one researcher and one local field assistant. We selected focal animals to try and evenly sample across age/sex classes. Focal animals were observed until they were lost from sight for a continuous period of over 10 minutes or could not be located again. Animals were not recognized individually. Field work took place between 0530 and 1900 hours. Follows started when

Table 1. Age/sex class definitions and sampling effort per class.

Age/Sex Class	Definition	Pooled sampling effort used in analysis
Adult Male	Animal of large body size with fully developed scrotal tuft.	2625
Adult Female	Animal of large body size with small genital tuft and/or prominent clitoris.	1998
Adult female with infant	Animal of large body size with small genital tuft and/or prominent clitoris carrying a dependent infant and/or seen to lactate.	1894
Juvenile Male	Animal of medium body size with underdeveloped scrotal tuft.	
Juvenile Female	Animal of medium body size with underdeveloped genital tuft and clitoris.	1887
Undefined Juvenile	Animal of medium body size whose sex could not be easily determined.	

Table 2. Behavioural categories and definitions.

	Behaviour	Definition
	Feeding	To forage for, handle, process or consume any food item (either plant part or animal prey).
	Resting	To be inactive in either a standing, sitting or lying position (either alone or in a group).
	Travelling	To change positions exclusive of incidental movement whilst foraging or engaged in another behaviour (either within or between trees).
Social behaviours	Play	To be actively engaged in repetitive, exaggerated and disjointed, solitary or social behaviour with no observable goal (exclusive of all other active behaviours).
	Sexual	To be engaged in copulation or related behaviours.
	Allo-grooming	To be primarily engaged in non-aggressive physical contact with another individual (either grooming or being groomed by another individual or individuals, exclusive of sexual contact).
Other behaviours	Auto-Grooming	To be primarily engaged in solitary grooming.
	Vocalising	To be primarily active in calling, exclusive of vocalisations during play, aggressive or sexual encounters.
	Aggression	To attack, provoke or show fear towards a conspecific from within the same group or with another group (including vocalisations, branch shacking, mooning and physical contact).
	Watching observer	To be primarily observant of the investigator(s) or field assistant(s).
	Out of sight	When visual contact was momentarily lost and the particular behaviour could not be seen clearly (exclusive of occasions when the individual could not be relocated).

a group was located and finished at sunset when the whole group became inactive after reaching a nesting site or when the group was lost or could not be followed because of inclement weather or topographical constraints.

#### Data collection

Data collection lasted 15 months between October 2009 and July 2010 and between September 2010 and February 2011. We made five day field trips twice monthly for the duration of the study and recorded point samples on a focal individual every two minutes on a standardized record sheet. We defined age/sex classes as follows: Adult male, Adult female, Adult female with dependant infant, Juvenile male; Juvenile female and Undefined juvenile (Table 1).

Eleven behavioural categories were chosen and defined: Feeding, Resting, Travelling, Vocalizing, Auto-Grooming, Allo-Grooming, Aggression, Sexual, Play, Watching observer, and Out of sight (Table 2).

#### Data analysis

We pooled the data between the three groups, as well as data from the three Juvenile categories (Table 1). This was done to provide sufficient data for analysis for each of the age/sex classes and behavioural categories across hours and months. We collected a total of 8431 behavioural data points, equivalent to 281 hours of data collection. We discarded data from the 'Watching observer' and 'Out of sight' categories prior to analysis, leaving 8404 behavioural observation points, equivalent to 280.3 hours of data collection.

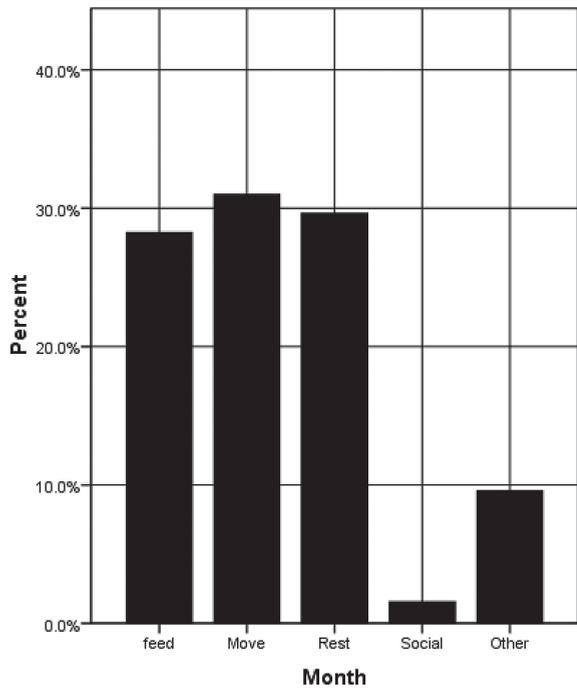


Fig. 2. Overall activity budget for *O. flavicauda* at La Esperanza.

We normalized all data between temporal, behavioural and age/sex classes before analysis.

We calculated daily, monthly and yearly activity budgets for individual age/sex classes and overall. Activity budgets were calculated using the proportion of points observed for each behaviour by each age/sex class for each of the different temporal scales (e.g. per hour, per month and overall). For analysis we grouped the behavioural categories into five discrete categories: Feeding, Travelling, Resting, Social behaviours, and Other behaviours. Because we did not regularly observe behaviours categorized as ‘Other’ they were only used in calculating yearly activity budgets.

### Results

#### Annual and monthly activity budgets

The yellow-tailed woolly monkeys at La Esperanza average 29.8% Feeding, 26.3% Resting, 29.0% Travelling, 2.3% in Social and 12.8% in Other activities (Fig. 2). Differences observed in annual activity

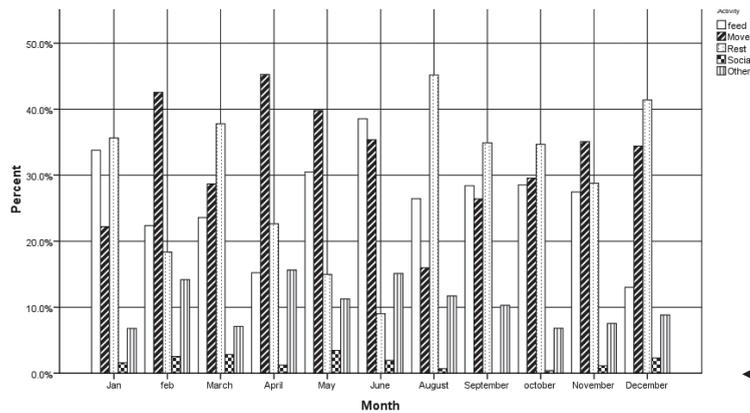


Fig. 3. Monthly activity budget for *O. flavicauda* at La Esperanza.

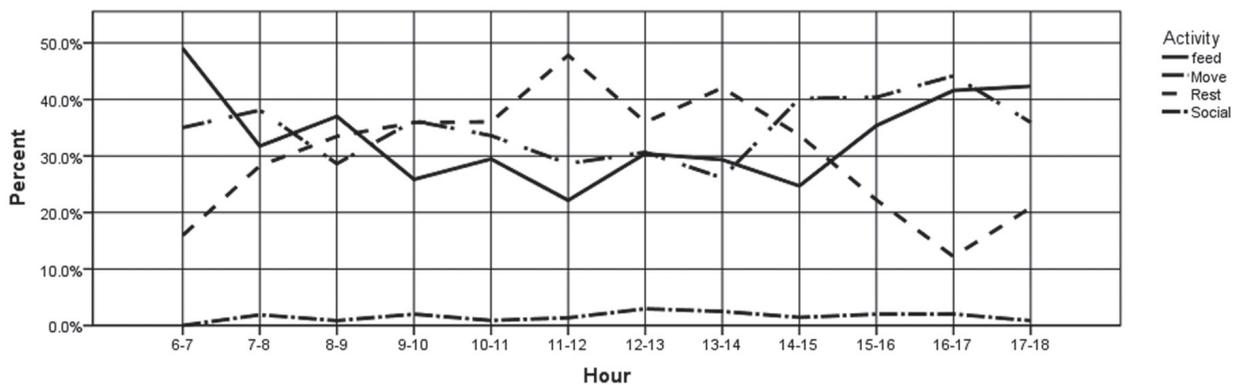


Fig. 4. Average diurnal activity budget for *O. flavicauda* at La Esperanza.

Table 3. Activity budget for *O. flavicauda* for different age/sex classes.

	Feeding (%)	Resting (%)	Travelling (%)	Social behaviour (%)	Other behaviour (%)
Adult male	21.2	33.4	30.5	1.3	14.4
Adult female	35.1	26.9	23.8	1.0	12.2
Adult female with infant	35.5	18.3	29.7	0.7	15.7
Juvenile	28.7	25.0	31.6	5.3	9.4
Mean	30.1	25.9	28.9	2.1	12.9
SD	6.7	6.2	3.5	2.2	2.8
Median	31.9	25.9	30.1	1.1	13.3
$\chi^2$	13.2	13.16	6.9	16.8	8.1
$p$ (df = 3)	$p < 0.05$	$p < 0.05$	$p > 0.05$	$p < 0.001$	$p < 0.05$

Table 4. Monthly time budget for *Oreonax flavicauda*.

Month	Feeding (%)	Resting (%)	Travelling (%)	Social (%)	Other (%)
January	35.9	31.3	23.5	2.3	7.1
February	19.6	19.1	32.3	5.1	23.3
March	37.2	13.4	37.3	4.3	8.9
April	22.1	23.4	33.7	1.8	19.6
May	34.8	15.5	31.9	4.3	13.6
June	41.3	10.5	27.8	2.5	18.4
July	28.9	45.2	13.8	0.7	13.5
September	28.3	29.6	32.8	1.3	8.5
October	30.0	35.8	27.1	0.6	6.6
November	29.6	35.9	25.1	0.0	9.4
December	10.9	37.5	38.1	3.1	11.2
Mean	29.0	27.0	29.4	2.4	12.7
SD	8.8	11.4	7.0	1.7	5.6
Median	29.6	29.6	31.9	2.3	11.2
$\chi^2$	26.48	47.71	16.64	12.4	24.23
$p$ (df = 10)	$p < 0.01$	$p < 0.01$	$p > 0.05$	$p > 0.05$	$p < 0.05$

budgets between age/sex classes were significant in all categories except travelling (Table 3). Significant differences observed in monthly activity budgets (Fig. 3) were Feeding, Resting and in Other behaviours (Table 4).

#### Diurnal time budgets

Figure 4 shows average diurnal time budgets. There is a significant difference from the expected value for resting ( $\chi^2 = 42.1$ , df = 11,  $p < 0.001$ ), with a peak around midday. There was significant difference from the expected value for feeding ( $\chi^2 = 36.4$ , df = 11,  $p < 0.001$ ), travelling ( $\chi^2 = 37.7$ , df = 11,  $p < 0.001$ ) and resting ( $\chi^2 = 97.4$ , df = 11,  $p < 0.01$ ) in adult males, with a peak in resting behaviour around midday and

associated drop in feeding and travelling behaviours at the same time. Juveniles showed similar activity patterns to adult males with significantly different values from expected for feeding ( $\chi^2 = 42.7$ , df = 11,  $p < 0.001$ ), resting ( $\chi^2 = 23.2$ , df = 11,  $p < 0.05$ ) and travelling ( $\chi^2 = 39.3$ , df = 11,  $p < 0.001$ ). Adult female behaviour differed significantly from expected values in travelling ( $\chi^2 = 40.1$ , df = 11,  $p < 0.001$ ) and resting ( $\chi^2 = 46.9$ , df = 11,  $p < 0.001$ ), however no significant difference in feeding was found. Adult females with infants showed a significant difference from expected values in feeding ( $\chi^2 = 35.6$ , df = 11,  $p < 0.001$ ), Travelling ( $\chi^2 = 37.36$ , df = 11,  $p < 0.001$ ) and Resting ( $\chi^2 = 57.6$ , df = 11,  $p < 0.001$ ) with a decrease in feeding and travelling and associated increase in resting around midday.

### Social and other behaviours

No significant differences were found in activity budgets for Social and Other Behaviours between age/sex classes or between months. Although juveniles were seen to engage in Play more than other age/sex classes this fell short of statistical significance ( $\chi^2 = 6.65$ ,  $df = 3$ ,  $p = 0.08$ ). Adult males and adult females with infants were observed vocalizing more often than the other age/sex classes. Adult males displayed more aggressive behaviours. Sexual behaviours were very rarely observed; we only recorded this behaviour on two occasions, both in January.

### Discussion

We found significant differences in activity budgets between age/sex classes. Adult females and adult females with infants spent more time Feeding than males or juveniles. This is probably because of the extra energetic requirements of natal care giving (particularly in lactating and expectant females) in this species that shows little sexual dimorphism with adult females of similar size to adult males (Key and Ross, 1999). Adult females with infants spent the least time Resting of all age classes (45% less than adult males). Juveniles spent by far the most time engaging in Social behaviours mainly in Play activities. We also found significant differences in monthly time budgets. Time spent Resting was highest in the dry season, between July and December. Although significant differences were found in Feeding and Other behaviours these were not concentrated at any time of the year.

Further observation is needed to determine birth seasonality as Sexual behaviour was only observed twice during January and multiple infants were present in all groups throughout the year. Because of the lack of studies on *O. flavicauda*, comparisons to our results and methods are impossible. We did observe similar behaviours to those reported by Macedo-Ruiz and Mittermeier (1979). We included Attack (*ataque*); Fear (*temor*) and Provoke (*provocacion*) in our Aggressive category. 'Regocijo' (joyfulness) was noted as play. Observations of other behaviours reported by Macedo Ruiz and Mittermeier (1979) were hard to determine as they were probably the result of the individuals solitary captivity. Villavicencio Cruz and Villalobos Gonzales (1991) made a short, less than 3 months, study of the behaviour of wild *O. flavicauda* in the Rio Abiseo National Park, San Martin. However they do not present activity budgets in their results so comparison is difficult. Behavioural categories used were similar to ours and those used by Macedo Ruiz and Mittermeier (1979), with the addition of Display and Miscellaneous behaviour, also the grouping of all interactions into a single category, including aggressive behaviours.

Activity budgets for other frugivorous Ateline primates vary widely between species and sites (Table 5). Our results are similar in most respects to those from studies of the *Lagothrix* species, although the percentage of occurrence of 'other' behaviours is much higher for *Oreonax*. However these differences could be partially due to differences in operational definitions of behaviours and categories used by other researchers. For *Lagothrix lagothricha* (von Humboldt, 1812) (*sensu* Fooden, 1967) fruit production

Table 5. Activity budgets for woolly monkeys and other Atelidae.

Genus	Species (Groves, 2001)	Species given in paper	Feeding (%)	Resting (%)	Travelling (%)	Social (%)	Other (%)	Reference
<i>Oreonax</i>	-	<i>flavicauda</i>	30.1	25.9	28.9	2.1	12.9	This study
<i>Lagothrix</i>	-	<i>lagothricha</i>	25.8	29.9	38.8	5.5		Defler, 1995
<i>Lagothrix</i>	<i>poeppigii</i>	<i>lagothricha poeppigii</i>	36.2	23.2	34.5	4.7	0.7	Di Fiore and Rodman, 2001
<i>Lagothrix</i>	<i>lugens</i>	<i>lagothricha</i>	36.0	36.0	22.2	5.8		Stevenson <i>et al.</i> , 1994
<i>Lagothrix</i>	<i>lugens</i>	<i>lagothricha</i>	36.0	35.0	26	3		Stevenson, 2002
<i>Ateles</i>	-	<i>belzebuth</i>	22.2	61.0	9.7	7.1		Klein and Klein, 1977
<i>Ateles</i>	-	<i>belzebuth</i>	18.0	45.0	36	1.0		Nunes, 1995
<i>Ateles</i>	-	<i>belzebuth</i>	16.7	58.2	24.9	0.1		Suarez, 2003
<i>Ateles</i>	-	<i>chamek</i>	29.0	45.0	26.0	-		Symington, 1988
<i>Ateles</i>	-	<i>geoffroyi</i>	33.5	24.1	32.6	9.8		Chapman <i>et al.</i> , 1989
<i>Ateles</i>	-	<i>geoffroyi</i>	10.8	54.1	27.6	7.5		Richard, 1970
<i>Ateles</i>	<i>chamek</i>	<i>b. chamek</i>	18.9	45.5	29.7	5.9		Wallace, 2001

related to soil fertility has been cited as a determining factor in activity budgets (Defler, 1995). There is no ecological data available to characterize soil fertility or food production at our site, although high elevation sites do generally have lower primary production levels (Caldecott, 1980; Marshall *et al.*, 2005; Shanee and Peck, 2008) than low land sites. On the other hand, habitat structure at our site, with areas of disturbed primary and regenerating secondary forest, could have higher production levels than un-disturbed sites at similar elevations (Lugo and Frangi, 1993). Preliminary data suggest a higher density of food sources at this site than in a neighbouring forest (Clark, 2009). The higher frequency of Other behaviours that we observed is due to the vocally active nature of the species. All age/sex classes were vocally active with daily bouts of vocalizations peaking during mid-morning (0800 - 1000 hrs) and again around midday (1100 - 1300 hrs). Adult males and adult females with infants were by far the most vocally active age/sex classes. Because of methodological differences in scoring vocal behaviours between this and other studies direct comparison with other woolly monkey species is not possible. The frequency of vocalizing peaked in early February and again in August. These peaks in vocal behaviour would coincide with mating and birthing seasons if mating is seasonal (occurring in January, the only month we observed sexual behaviours) and given a gestation length similar to that of common woolly monkeys (DiFiore and Campbell, 2010). However more research is needed into the species mating behaviour before conclusions can be drawn.

Differences to the closely related spider monkeys (*Ateles* spp.) are much larger; particularly in reference to *Oreonax*'s generally greater time spent feeding and lesser time spent resting. Our observations suggest that yellow-tailed woolly monkey groups are more cohesive than spider monkey groups, although like spider monkeys they do display some fission-fusion style behaviours (Shanee and Shanee, 2011). Fission in *Oreonax* appears to be more similar to that of common woolly monkey (*Lagothrix lagothricha*, *sensu* Fooden, 1967; Defler, 2004) groups which do not separate for extended periods of time, over extended distances, or as frequently (unpublished data). Additionally home range sizes and daily path lengths for yellow-tailed woolly monkeys are much smaller than those of spider monkeys (Shanee and Shanee, unpublished data) and some common woolly monkeys (Defler, 1995). These differences in group structure and

ranging could be related to the observed differences in activity budgets. Both spider monkeys and woolly monkeys are primarily frugivorous. At high elevations lower quality habitat would necessitate a greater time spent feeding and favour smaller, more cohesive groups rather than expanding range sizes (Shanee, 2009) to reduce inter- and intra-group feeding competition for scarce resources. With increased altitude primary production levels fall (Lawes, 1992; Smith and Killeen, 1998; Costa, 2006; Bendix *et al.*, 2008; Shanee and Peck, 2008), variations in the diet of frugivorous primates between low and high elevations have been documented (Hanya *et al.*, 2003; Sayers and Norconk, 2008) generally showing a reduction in fruit consumption with increased elevations, with a greater reliance on other plant matter. Unfortunately little data exists on the nutritional composition of *O. flavicauda* diet, although ripe fruits constituted 71% of observations in a previous study (Shanee and Shanee, 2011).

Further behavioural studies are needed from other sites to enable proper comparison with our results. Particular emphasis should be put on studying groups at sites with different habitat types and at different elevations. Field conservation of *Oreonax flavicauda* is of high priority. In recent years various new protected areas have been created for the protection of this species (Buckingham and Shanee, 2009) which could provide opportunities for researchers to study this species in a variety of habitats with differing levels of anthropogenic disturbance and threat.

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