

Short Communication

Preliminary observations on the behavior and ecology of the Peruvian night monkey (*Aotus miconax*: Primates) in a remnant cloud forest patch, north eastern Peru

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Abstract:

The Peruvian night monkey (*Aotus miconax*) is endemic to the eastern slopes of the Andes in northern Peru. We present preliminary behavioral data on *A. miconax* collected during 12 months of surveys on a single group living in a 1.4 ha forest fragment near the *Centro Poblado La Esperanza*, Amazonas Department. Follows were conducted for five nights each month around full moon. The group used 1.23 ha as their home range. Night ranges were between 0.16 and 0.63 ha. Activity budgets were 32 % feeding, 53 % travelling and 13 % resting. Average night path length was 823 m and average travel speed was 117 m/h. The study group has one of the smallest home ranges recorded for a night monkey group, probably the result of its isolated habitat. These results represent the first behavioral data on this species but results are limited by small sample sizes. *A. miconax* remains one of the least studied of all primates and is threatened by continued expansion of human populations and hunting.

Key Words: Owl monkey; Ranging; Fragmentation; Activity Budget; Conservation

Resumen:

El mono nocturno peruano (*Aotus miconax*) es endémico de las laderas orientales de los Andes, al noreste del Perú. Presentamos información preliminar sobre el comportamiento de *A. miconax* colectado durante 12 meses de estudios sobre un grupo ubicado en un fragmento de bosque de 1.4 ha, cerca del Centro Poblado La Esperanza, Departamento de Amazonas. Las observaciones se llevaron a cabo durante cinco días cada mes alrededor de la luna llena. El grupo tuvo un rango de distribución de 1.23 ha dentro del fragmento. El rango de distribución por noche varió entre 0.16 y 0.63 ha. Los presupuestos de actividad fueron de 32% alimentándose, 53% viajando y 13 % descansando. Promedio de desplazamiento nocturno fue 823 m y velocidad de desplazamiento promedio fue 117 metros por hora. El grupo en estudio, muestra uno de los hábitats más pequeños registrados para un grupo de monos nocturnos; aunque esto, probablemente, sea el resultado de su hábitat aislado. Estos resultados representan los primeros datos sobre el comportamiento de esta especie, aunque estos resultados aún son limitados por los reducidos tamaños de muestra. *A. miconax*, sigue siendo uno de los primates menos estudiados y se ve amenazado por la continua expansión de las poblaciones humanas y la caza.

Palabras clave: Mono nocturno, Rango, Fragmentación, Presupuestos de actividad, Conservación.

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Introduction

The Andean night monkey (*Aotus miconax*) is one of the least studied of all Neotropical primate taxa. *Aotus miconax* is endemic to northeastern Peru [1, S. Shanee unpublished data], a threatened area characterized by high levels of endemism [2, 3]. *Aotus miconax* is limited to cloud forests between 1200 and 3000 meters above sea level (S. Shanee unpublished data). This species is listed as Vulnerable by the IUCN (Red List categories A2c) and Endangered under Peruvian law (*Decreto Supremo* 34-2004-AG). The current IUCN listing does not accurately represent the species' actual conservation status, underestimating habitat loss and fragmentation. The species would probably be better considered Endangered under the same categories (A2c).

Aotus miconax has not been the focus of previous behavioral studies, although some behavioral observations have been made [4, 5]. Aside from these studies, it is only known from collection localities in the departments of Amazonas, Huánuco and San Martín [4-7]. These same departments have some of the highest deforestation rates in Peru [8, 9]. Deforestation in the area is fueled by immigration of people from the central and northern highlands looking for land for agriculture, cattle ranching and timber extraction [10-12]. Patterns of land use and ownership have caused the fragmentation of forests, forming an anthropogenic landscape mosaic [12, 13].

Fragmentation can severely affect primate ecology, reducing the area available for foraging, limiting migration opportunities, causing changes in ecology, group structure and demography as well as disrupting genetic flow between populations and increased risk of parasite infections [14-18]. Fragmentation also increases exposure of primates to anthropogenic threats [19-22]. Species living in heavily fragmented forests and isolated patches face additional challenges to their survival and often develop new ecological strategies to enable them to persist in the new landscape [15, 23]. Many differences exist in species' responses to living in fragmented forests; those that are successful usually show a high degree of behavioral and dietary plasticity and the ability to utilize outlying areas [15, 23, 24]. Specifically, studies have suggested reduced presence and an increase in parasite load in *Aotus* spp. in fragmented forests [18, 25], although studies of *Aotus miconax* and the Colombian night monkey (*Aotus lemurinus*) have shown adaptability to living in forest fragments [23, 24].

In natural conditions *Aotus* spp. live in small groups of two to six individuals (personal observation). These groups generally comprise an adult hetero-sexual pair with one to four juveniles and infants [26]. The diet of night monkeys is primarily frugivorous although leaves,

buds and insects also figure in their diet [27, 28]. Fruiting figs (*Ficus* spp.) are a preferred food source in all studied species [26]. *Aotus* spp. are primarily nocturnal although some species are cathemeral, active nocturnally and diurnally [29-31]. Both nocturnal and diurnal activity is influenced by moon luminosity [27, 31]. Results from the few previous studies show that *Aotus miconax* has group structure and behaviours similar to those of other *Aotus* spp. [5, 23, 32].

We aimed to gather preliminary data on the behavior, diet and ecology of a group of *Aotus miconax* to provide data from which to design and analyze future studies of this poorly known species. We conducted night follows and *ad-libitum* data collection in a small forest fragment within a mosaic landscape. This was done to provide baseline data on the species and the interactions between night monkeys and their habitat in an anthropogenic environment.

Methods

Field work took place in the *Comunidad Campesina Yambrasbamba*, Amazonas department, Peru (Fig. 1). The area is a mosaic of disturbed primary and regenerating secondary cloud forests. In areas closer to human settlement this landscape becomes steadily less forested, with isolated fragments of ~ 0.5 ha to ~ 10 ha surrounded by pasture and small cultivated plots. Riparian forests and living fences are common, allowing at least partial connectivity between patches. The area lies on the eastern slopes of the Andes with elevations between ~ 1800 and 2400 meters a.s.l. Terrain is rugged with steep river valleys separated by high mountain ridges. Temperatures are cool, 10 to 25 °C in the day, dropping to 6 °C before dawn. Rainfall is heavy year round, with a drier season from June to November and wetter season from December to May. Average monthly rainfall is ~ 1500 mm.

The focal group lived in a small ~ 1.4 ha isolated forest patch, approximately one km from the closest neighboring patch (Fig. 1) near the village of La Esperanza (S 05°42'17", W 77°54'14"). The patch consisted of disturbed remnant cloud forest vegetation with a mix of primary and secondary species with all large timber species removed > 20 years ago. Trails were cut in a 10 x 10 meter grid, creating a series of 100 m² quadrants; all intersections were tagged. Observations were recorded directly onto maps showing the quadrants.

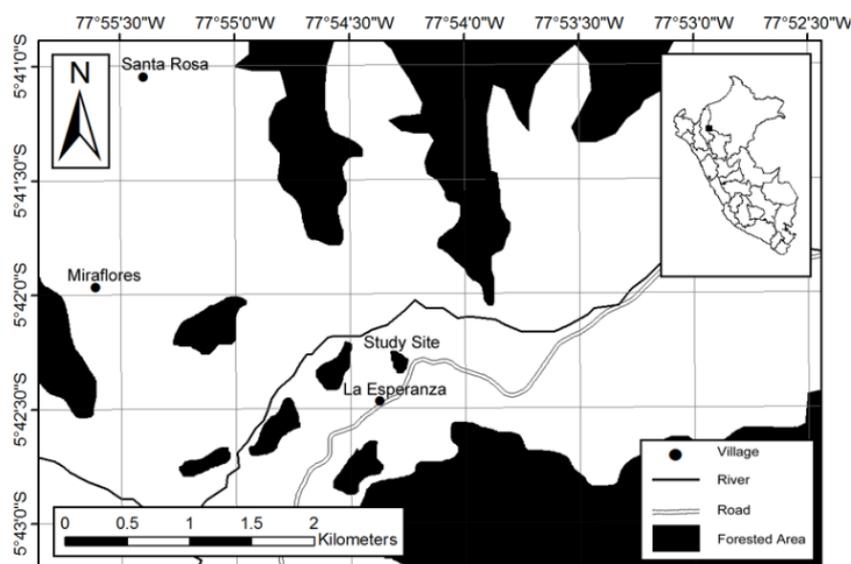


Fig. 1. Location of study site showing forested and deforested areas.

Observations took place on a single group. At the start of the study the group consisted of five individuals (two adults, two sub-adults/juveniles and one infant). One individual was born in April 2010, leaving six individuals at the end of the study (two adults, three sub-adults/juveniles and one infant). Determination of age classes was subjective, based on comparison of size and genital visibility.

Data collection was carried out for 12 months between January and June 2010 and September 2010 and February 2011. Two follows were conducted each night, between ~ 18:30 – 22:00 hours and 03:00 – 06:30 hours for five consecutive nights each month. These times were chosen because previous studies of *Aotus* spp. suggest generally higher activity levels during these hours [31, 33]. As this was a preliminary study and because of time constraints, we carried out observations during nights when natural visibility would aid observation. Our night follows took place on days around the full moon (between 80 – 100% illumination of the moon's surface). We were not always able to carry out follows during the same range of nights, e.g. not always two days before and after the full moon. Light intensity was variable with shifting cloud cover during most follows.

Of the 60 nights of data collection we abandoned 23 follows. Follows were abandoned due to inclement weather or when the group was lost near the start of a follow and we were unable to relocate it. One further follow was dropped from analysis because the group was clearly influenced by the presence of observers, emitting distress vocalizations and travelling away from observers without pause for the first two hours of the follow. This left 36 half-night follows totaling 69.2 hours of observation (avg. 112.2 minutes per follow). These were distributed unevenly between six morning follows and 30 evening follows. Night ranges were calculated using data from nights when both evening and morning follows were completed successfully ($n = 6$). We made follows in groups of one to three trained observers, using red light, conventional and high power 1.25 watt CREE flashlights. We avoided shining high-power beams directly at observed individuals, especially over short distances.

When the group was identified, it was already well habituated to the presence of humans due to the proximity of the village of *La Esperanza* and outlying houses. Also, local residents regularly pass through the fragment and many use it as a source of firewood. No particular habituation schedule was followed, although we furthered the habituation process prior to the study whilst testing methodologies and preparing transects.

Individuals were not recognized and so observations were made on the group as a whole using scan sampling methodology [34]. Position of the group was recorded as whichever quadrant contained the majority of visible group members, or whichever quadrant had the highest number of group members in the case of the group being spread across more than two quadrants. We used continuous scan sampling methodology and recorded the predominant behavior displayed by a majority of visible group members, discounting non-locomoting infants [34]. Group behaviors were divided into four discrete categories: feeding, traveling, resting and other. Other behaviors were noted separately and not used in overall activity budgets as they were rarely observed. Night ranges were calculated as the number of grid cells used by the group during nights when both evening and morning follows were completed. Travel speed was calculated as the minimum distance, parallel with or diagonally across grid squares, per hour, thus representing a minimum estimate.

We also collected data on diet. Food types were separated into five categories: fruit, flower, leaf, bud (inclusive of flower and leaf buds) and insects. Data on food sources were collected through direct observation during feeding bouts. Attempts were made at field identification

of arboreal food sources. When this was not possible samples were collected for later identification at the *Universidad Nacional Toribio Rodriguez de Mendoza de Amazonas*.

Results

Travel and home range:

Average travel speed was 117 ± 43 meters per hour (min = 50 m/h, max = 190 m/h). The slowest travel speeds were observed during the dry season in September (50 m/h, n = 3), with highest travel speeds occurring during the wet season in April (190 m/h, n= 5) (Table 1). There was no significant difference found in travel speeds between seasons ($\chi^2 = 0.98$, df = 1, $p = 0.32$). Average night path length, based on our partial night follows, was $823 \text{ m} \pm 304$ (min = 339 m, max = 1,314 m). Average night path length was similar between seasons (766 m wet season and 800 m dry season); the difference was not statistically significant ($\chi^2 = 0.39$, df = 1, $p = 0.85$) (Table 1).

The group used $\sim 88\%$ of the patch as their home range (Fig. 2). Most of the available habitat ($\sim 54\%$) was used on less than 20% of follows, with only a small portion of available area ($\sim 4.3\%$) used regularly. Night range averaged 0.44 ± 0.19 ha (min = 0.16 ha, max = 0.63 ha). Seasonal ranges were; 0.42 ha in the wet season and 0.67 in the dry season, although the difference was not statistically significant ($\chi^2 = 0.81$, df = 1, $p = 0.36$) (Table 1).

Table 1. Monthly activity budgets and ranging behaviours.

Month	Feeding (%)	Travelling (%)	Resting (%)	Average travel speed (m/h)	Average night path length (m)	Average night range (ha)
January	33	64	3	100	710	0.65
February	33	54	12	140	970	0.41
March	37	33	29	100	660	0.30
April	16	65	17	190	310	0.57
May	41	50	8	090	640	0.42
June	25	67	6	080	550	0.21
September	33	58	8	050	330	0.53
October	27	38	33	130	900	0.68
November	43	54	2	120	850	1.08
December	35	49	15	180	1250	0.40

Activity Budget:

The focal group was active during all observation hours. The group left their sleeping site between 17:46 hrs and 18:56 hrs (n = 31, including abandoned follows) and re-entered the sleeping site between 05:28 hrs and 06:28 hrs (n = 7), always leaving and returning to the nest during daylight hours. The focal group averaged $33 \pm 7\%$ of their time feeding, $54 \pm 11\%$ travelling and $13 \pm 11\%$ resting (Table 1). Bouts of resting averaged 18 ± 13 mins. No significant difference was found in time spent feeding ($\chi^2 = 0.62$, df = 1, $p = 0.43$), travelling ($\chi^2 = 0.56$, df = 1, $p = 0.45$) or resting ($\chi^2 = 0.71$, df = 1, $p = 0.39$) between seasons.

Diet

The diet of the focal group consisted of 42 % fruits, 5 % flowers, 6 % leaves, 25 % buds and 19 % insects. In total 22 plant species, 21 trees and one vine were consumed. Arboreal food sources included naranjillo (*Styloceras laurifolium*), huarumbo (*Cercropia montana*), huarumbo (*Cercropia utcubambana*), casaco (*Hyeronima andina*), higueron (*Ficus eximia*), higueron (*Ficus* spp.), llajas (*Casearia decandra*), caimito (*Chrysophyllum venezuelanense*),

palmera (*Ceroxylon peruvianum*), *Neosprucea montana*, cocona (*Solanum* sp.), guaba (*Inga feuillei*), guaba (*Inga* spp.), indano (*Bunchosia armeniaca*) and tumbe (*Styrax* sp). A further eight species still need to be identified.

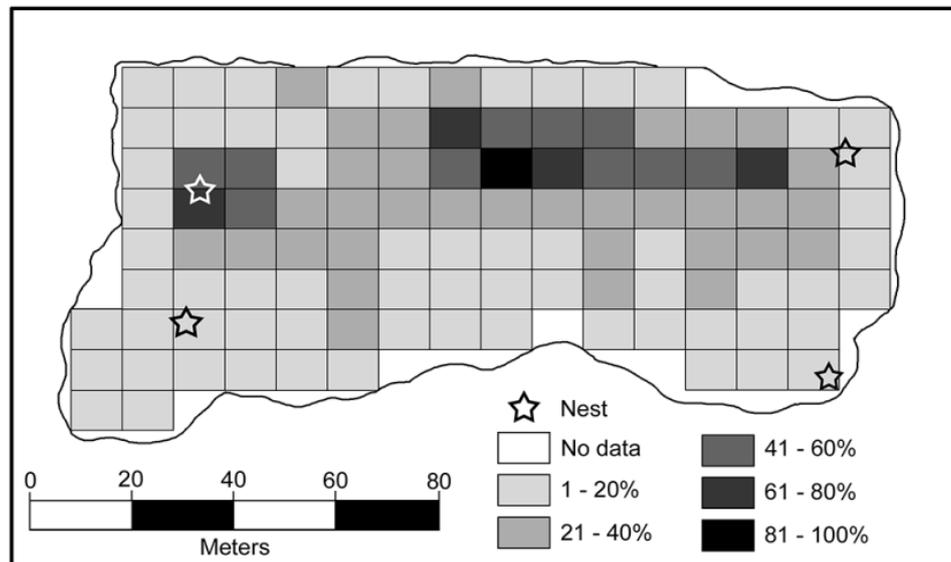


Fig. 2. Map of forest patch showing frequency of use for each quadrant.

Other observations

We never witnessed diurnal activity. Cathemeral behavior was inferred on three occasions when the group was left at a sleeping site in the morning but was not encountered at the same sleeping site in the evening.

The focal group used at least five sleeping sites during the study period, one located in a tree hole and three in vine tangles. Although we were not able to locate the fifth sleeping site, we observed the group starting and finishing their activities from the same area on a number of occasions. During observations the group changed sleeping site every three to five days. All nests were in the mid and lower story between five and ten meters above the ground.

Most vocal activity was between 19:00 and 21:00 hrs. Vocal behaviors were only observed once during morning follows. Vocal bouts did not last long, usually consisting of a short series of grunt-barks, lasting less than two minutes. On one occasion we observed the whole group vocalizing for eight minutes; this extended vocal bout took place on a full moon night. Vocalizations often accompanied scent marking activity.

Discussion

These results represent the first ecological data on this species. The limitations of this study mean that results may not be representative of the species' ecology in natural, un-disturbed habitats, but do provide much needed preliminary data. Studies of strictly nocturnal night monkey species using direct observation are extremely difficult. This was made more difficult in the rugged cloud forest habitat of *Aotus miconax*. Continuous scan sampling has been used successfully in a previous study of *A. lemurinus* [24] and provides a simple and effective way of calculating activity budgets when recognition of individual animals is not feasible. Our results are preliminary and as such provide only baseline information for future studies. It is

likely that the non-significant correlations and differences reported here are due to small sample size. Similarly, group scan sampling biases against rare behaviors.

Published activity budgets for *Aotus* spp. are highly variable [35-37]. Our study group spent more time travelling and less time resting than recorded for other species (Table 2). In a study of *Aotus lemurinus* in Colombia [24], the only other *Aotus* species restricted to high elevations, a similarly low percentage of time was spent in resting, suggesting extra energetic costs are incurred for successful foraging at high elevation sites. It should be noted that our results probably underestimate time spent resting. On occasions when the group was lost they could have been resting. Conversely we probably overestimate the proportion of conspicuous behaviors. We tried to minimize this with prolonged searches in the area where the group was lost. Not conducting follows between 22:00 hrs and 03:00 hrs will also have biased results towards active behaviors. In the Argentinean Chaco Azara's night monkey (*A. azarae azarai*) showed peaks of activity during twilight hours, with more time spent resting later in the night [30, 31]. The disturbed and fragmented nature of the habitat may have contributed to the greater time dedicated to active behaviors, although this could be counterbalanced by secondary forests generally having higher primary production levels than primary forests [38] and by small fragments reducing travel distances and range sizes.

Table 2. Activity budgets for night monkey species.

Species	Sampling method	Feeding (%)	Travelling (%)	resting (%)	Other (%)	Source
<i>A. miconax</i>	Scan sampling (continuous)	32.8	53.7	13.44	-	This study
<i>A. azarae boliviensis</i>	Scan sampling (5 minute intervals)	31.7	19.8	49.4	-	Garcia & Braza 1987
<i>A. brumbacki</i>	Instantaneous and scan sampling	15.0	32.0	33.0	16.0 Vocalizing 3.0 Social	Solano 1995
<i>A. nigriceps</i>	Scan sampling (5 minute intervals)	53.0	21.0	22.0	4.0 Agonistic	Wright 1981
<i>A. lemurinus</i>	Scan sampling (continuous)	50.5	39.6	4.9	1.7 Vocalising 1 Social 2.2 Other	Castano et al 2010

Quantifying dietary intake of strictly nocturnal *Aotus* spp. presents many difficulties. Our results are similar to those from previous studies, showing a predominantly frugivorous diet. Leaf consumption has also been regularly observed, although *A. a azarae* and Panamanian night monkey (*A. zonalis*) showed much higher levels of leaf consumption than we found. These studies did not differentiate between leaves and buds [26]. Insect prey is commonly consumed, although only studies of Brumback's night monkey (*A. brumbaki*) and *A. lemurinus* have recorded levels as high as this study, 28 % and 28.2 % respectively [24, 36]; variations in methodologies again limit the possibility of direct comparisons.

Published home range sizes for *Aotus* species are also variable [24, 26, 35, 36, 39]. Comparisons with results from studies in undisturbed forests are difficult because our study was carried out in an isolated forest patch. Studies of both *Aotus azarae boliviensis* and *A. lemurinus* in isolated patches have recorded smaller home ranges [24, 35]. The ability to persist in small fragments suggests that, at least in the short term, *Aotus* are able to adapt to

anthropogenic habitat alteration. Observations of *A. miconax* have shown adaptability to heavily altered environments [24], living in shade grown coffee plantations (S. Shanee unpublished data) and even displaying terrestriality to access scarce food resources [23]. Night ranges, area used in a single night, for *Aotus* spp. show less variability than home ranges, with no study recording a night range greater than one ha. The average night range found in this study is within the expected range.

Our estimate of home range size represents a minimum of the actual space used by this group. For example, on a number of occasions the group was seen to descend to the ground and leave the forest patch to access isolated food sources [23]. On another occasion a follow had to be abandoned after the group travelled past the northern edge of the patch where the ground falls away in a vertical rock face. We could not relocate the group that night and assume they descended the cliff face. How much difference this will make in range size is difficult to determine as resources outside of the home patch are scarce and located nearby. These forays outside of the normal home range are probably necessary for the group to survive in the forest patch. The need to utilize resources outside of the group's home patch could have been necessary because of the unusually long dry season during this study.



Fig. 3. Clockwise from top left: Study group in vine tangle nest (copyright Sam Shanee/NPC); Adult from study group in nest in hollow tree trunk (Copyright Jean Paul Perret/NPC); Undisturbed forest habitat of *A. miconax* (Copyright Sam Shanee/NPC); Fragmented forests near La Esperanza study site (Copyright Sam Shanee/NPC).

Implications for conservation

The continued presence and reproduction of *Aotus miconax* in this heavily disturbed area suggests that the species is able to survive in isolated habitat close to human settlement; therefore the conservation of forest fragments is of importance (Fig. 3). Special emphasis should be made in preserving connectivity to allow genetic flow between groups [15]. Castano *et al* [24] found similar adaptation to anthropogenic landscapes in *A. lemurinus*, giving further evidence of the adaptability of *Aotus* spp.

Even though this and other studies have shown that *Aotus* spp. have sufficient ecological plasticity to adapt to forest fragmentation, further studies of the species' adaptability to anthropogenic landscapes are needed to aid in conservation planning. Particular attention should be given to the genetic consequences of fragmentation on *Aotus* spp. We also recommend surveys of wild populations in primary forest sites to provide data on the species' natural ecology.

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