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OBSERVATION OF SNAKE (COLUBRIDAE) PREDATION BY YELLOW-TAILED WOOLLY MONKEYS *(LAGOTHRIX FLAVICAUDA)* AT EL TORO STUDY SITE, PERU

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Introduction

Primates display a wide variety of dietary preferences (NRC, 2003; Hublin and Richards, 2009) with the majority of species being to some extent omnivorous (NRC, 2003; Hublin and Richards, 2009). Generally, dietary strategies of primates are linked to body size, with food quality and levels of animal predation decreasing as body size increases (Ford and Davis, 1992). Nevertheless, neotropical primates of similar body size often show adaptations to different diets (Ford and Davis, 1992). Protein intake is a limiting factor in the primate diet; for maintenance of body mass, growth and reproduction (NRC, 2003; Ganzhorn et al., 2017). Whereas smaller bodied species can easily meet their protein requirements by feeding on insects, this is not a feasible strategy for larger bodied species (Ganzhorn et al., 2017).

Large bodied species, including *Lagothrix* spp., supplement their diets with leaves, which have higher protein content than fruits (Ganzhorn et al. 2017), and/or arthropods (Barnett et al. 2013). Another strategy available is to prey on smaller vertebrates. Vertebrate predation is a widespread but infrequent behaviour across primate taxa (Butynski, 1982; Fedigan, 1990; Hublin and Richards, 2009; Falótico et al., 2017). Most reports of vertebrate predation in primates come from Old World primate species. Neotropical primates are not considered as successful vertebrate predators as Old World ones (Fedigan, 1990) but, actually, most field research has focused on largely terrestrial rather than arboreal species (Butynski, 1982).

Reports of primate-snake interactions normally focus on predation of the primates involved, for example predation of *Saguinus*, *Saimiri*, *Cebus*, *Alouatta* and *Chiropotes* by boa constrictors *(Boa constrictor)* in the Neotropics (Cisneros-Heredia et al., 2005). Similarly reports exist of predation on Old World primates by reticulated pythons (*Python reticulatus*) (Quintino and Bicca-Marques, 2013). Observations of snake predations are even rarer, perhaps because of the risks involved, humans being the only primate to regularly predate on snakes (Falótico et al., 2017). To our knowledge, two reports do exist, one of *Tarsius bancanus* consuming a *Calliophis intestinalis* (Niemitz, 1973), and the other one in captive *Leontopithecus chrysomelas* and a

reintroduced *Leontopithecus rosalia* preying on coral snakes (*Micrurus* sp.) (Pissinatti in press, in Falotico et al. 2017), although in both cases the primates died from the snakes´ venom (Falótico et al., 2017).

The yellow tailed woolly monkey (*Lagothrix flavicauda*) has a varied diet comprising fruits, leaves, insects, petioles and other plant parts (Shanee and Shanee, 2011a, 2011b; Shanee, 2014). Recent observations also described geophagy in this species (Fack, 2016). To date, no reports have been made of animal predation, including snakes, by *L. flavicauda*. Here we present the first two observations of predation of a snake in a wild group of *L. flavicauda*, occurring in the dry season.

Methods

Our observations were collected during behavioural follows on a group of *L. flavicauda* at the locally named "El Toro" field site (05°40'83.2"S, 77°55'02.0"W), in the *Comunidad Campesina Yambrasbamba*, located on the eastern slopes of the Andes in Amazonas department, northern Peru. The study site comprises approximately 700 ha of disturbed montane cloud forest, pastures and agricultural lands between 1,800 and 2,400 m a.s.l. (Shanee and Shanee, 2015).

Data were collected on a group of 21 individuals of habituated *L. flavicauda*.: four adult males, eight adult females, four juvenile females, two juvenile males and three infants. Data were collected using instantaneous focal animal sampling (Altmann, 1974) during full day follows by one researcher and one local field assistant. Follows were undertaken on six consecutive days every two weeks, between 06:00 and 18:30 hours during April 2016 and August 2017, both during the dry season.

Results

At 14:15 pm on the 6th of April 2016, the focal individual, an adult male apart from the social group, was seen holding a dead snake of the family Colubridae while resting on a branch ~10m above the ground in a low tree (~13m). As it was raining at the time we were not able to observe the initial interaction between the *L. flavicauda* and the snake, therefore we do not know if it was found dead or killed by the focal individual. The focal individual then moved slowly to another tree, again to rest (~11m off the ground in a larger tree, ~15m). During this time, the focal individual was seen visually inspecting the snake, without vocalizing. At 14:25 pm the focal animal moved again, still holding the snake, to rest in another tree (~6m off the ground in a small tree, ~8m). Here the focal was within 2m of another adult male from the group, but no interaction was observed between the males. At 14:30 pm, the focal individual moved again, to the canopy (~15m) where he consumed immature leaves of *Ficus spp.* During this last move he let the snake fall to the ground; it was not recovered by another group member.

At 11:25 am on the 9th of August 2016, the focal individual, an adult female, was observed holding a live green snake, again a member of the Colubridae, in her left hand whilst moving through the canopy (~16m). The individual was alone, as she had separated from the rest of the subgroup we were following. Again, we did not see the initial encounter between the focal individual and the snake. Whilst moving towards the rest of the sub-group, the focal individual was observed by the other members and was approached by a juvenile male. However, the female did not allow the juvenile to approach too close, holding him away with her free hand. At 11:40 am the focal individual foraged on a dry branch while still in close proximity to the juvenile male and another adult male from the group. At 11:50 am the focal individual was observed manipulating the snake while resting, spinning it around her to avoid being bitten, as the snake, open mouthed, was seen trying to bite the female's arm. At 11:55 am, the sub-group started to travel faster and the focal female followed them. After a short moment out of our sight, we relocated the focal individual resting in a tree, with the snake, now dead, still in her left hand. The tail of the snake showed clear damage from being bitten.

At 12:00 pm the female began eating the snake starting with the tail, combining it with immature leaves and dry branches. Then she bit the snake in two and took a half in each hand. She kept one half in her hand while eating the other. An adult male and a juvenile male were observed approaching from ~20 m away. At 12:55 pm, the juvenile male attempted to snatch the snake from the female, but she fended him off. She continued to eat the snake, finishing the posterior half first then consuming the anterior part. She ate this until reaching the head. At 2:00 pm the focal individual finished eating and dropped what remained of the snake's skin. The female then re-entered the group, allowing other members to approach, and continued to rest and travel in the group. During this time, some "search-find" vocalizations were emitted by other members of the sub-group when the focal individual was isolated.

Discussion

Among primates, predation behaviours are mostly expressed by humans, chimpanzees and baboons (Butynski 1982). However, vertebrate predation by non-human primates has been recorded in at least 38 species from 9 families of prosimian and New and Old World monkeys and apes (Butynski 1982). Neotropical primates, including woolly monkeys, have been recorded predating on a variety of vertebrate including lizards, birds (adults and nestlings), squirrels, bats and coatis (Butynski 1982; Fedigan 1990).

To our knowledge, this is the first record of snake predation by *Lagothrix flavicauda*. This report increases our

knowledge about the diet and ecological interactions of this species. Even if it is a very rare event, it may highlight several important factors in their behavioural ecology, namely additional protein sources in their diet, the potential to discriminate venomous and non-venomous prey (Falótico et al. 2017), as well as providing a defence against potential predators (Cisneros-Heredia et al. 2005), as snakes have even been observed to prey on large bodied Atelidae (Quintino and Bicca-Marques 2013).

Observations of snake predation by non-human primates may be rare because of the potentially high risk involved. The few published reports all involved small and medium bodied primates, such as *Tarsius bancanus* (Niemitz, 1973), *Leontopithecus chrysomelas*, *Leontopithecus rosalia* (Pissinatti in press, in Falotico et al. 2017) and *Sapajus libidinosus* (Falótico et al. 2017). Falótico et al. (2017) reported that *Sapajus libidinosus* are able to differentiate between venomous and non-venomous snakes, in Brazil. They emit different cues according to the type of snakes, eliciting different responses from other group members (Falótico et al. 2017). Discrimination could have been made according to the size: small snakes were more often prey, although they can be more dangerous. Other factors may have also played a discriminatory role, such as colour and contrast colours, as well as audio cues. In both of our observations the prey snake was a member of the Colubridae, of a small, light green species. In our second observation, the focal individual was observed holding a live snake, without showing any obvious signs that the snake was considered a threat, although she did try to avoid being bitten. Similarly, we did not note any mobbing type behaviour (Crofoot, 2012) by other group members. Mobbing in the presence of venomous snakes has been reported in *S. libidinosus* by Falótico et al. (2017) and observed in *L. flavicauda* at this site, in response to the presence of a coati, *Nasua nasua* (Fack, Unpublished data).

To further these observations, it is necessary to begin an inventory of the snake species present at our study site and to record more interactions between *Lagothrix flavicauda* and snakes to determine how they behave towards different snake species and in which cases they could be predators or preys of snakes.

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UNEXPECTED DIVERSITY: THE POTENTIAL ROLE OF PRIVATELY-OWNED FOREST REMNANTS IN THE CONSERVATION OF THE PRIMATES OF THE HIGHLY-IMPACTED RONDÔNIA CENTER OF ENDEMISM, SOUTHWESTERN BRAZILIAN AMAZONIA

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The Rondônia center of endemism is an important component of Amazonian diversity, with a total area of 675,454 km2, which is mostly (96%) located within Brazil (da Silva *et al.*, 2005). Ongoing deforestation and logging have caused extensive habitat loss and fragmentation within this area, and constitute the main threat to its biodiversity (Gascon *et al.*, 2001). Some 27% of this area is protected, although only 3% is located within strictly protected conservation units (da Silva *et al.*, 2005). The primate diversity of the left margin of the Ji-Paraná River in southwestern Brazilian Amazonia is well known (Ferrari *et al.*, 1996; Gusmão *et al.*, 2014), although data from the right margin, especially from the middle and upper reaches of the river, are still scarce, and mostly outdated (Miranda-Ribeiro, 1914; Allen, 1916; de Vivo, 1985; Iwanaga and Ferrari, 2001). The present study reports on the primate assemblage found in an isolated forest remnant on the right margin of the upper Ji-Paraná River.

The study was conducted in a forest remnant of 543 ha located within a pasture matrix (11°28'08.81" S, 61°21'27.49" W), 229 m a.s.l., in the municipality of Cacoal, Rondônia state, Brazil (Fig. 1). This forest fragment is an area that combines the legal reserves of a number of small- and medium-sized farms. The climate is tropical humid (Aw in Köppen's classification) with a well-defined rainy season between September and May and a mean temperature of 26°C (Alvares *et al.*, 2013).

Data on the occurrence and abundance of primates within the study area were collected by line transect survey (see Peres, 1999), in which trails are walked at a mean velocity of 1.5 km/h. In the present study, the transects were conducted on two pre-existing trails; one 1.1 km in length, and the other, 0.7 km long. During these surveys, each encounter with a primate group was recorded, in which the species was identified and group size determined. Complementary data were collected during an ecological study of *Lagothrix cana* in the fragment, between March and September 2017 (Cavalcante, 2018). This study included 322 hours of behavioral monitoring, during which sightings of other primate species were recorded opportunistically, as well as during the phenological monitoring of seven 250 m trails scattered throughout the fragment. A total of 17.5 km was covered during the phenological surveys. Photographic records were obtained of all primate species, and their identification was confirmed through comparisons with the literature (Mittermeier *et al.*, 2013; Marsh, 2014; Byrne *et al.*, 2016).

Results and Discussion

We recorded 10 primate species during the present study, representing five families (Table 1). *Saimiri ustus* was by far the most abundant species, in terms of both the number of sightings and group size, whereas *Pithecia mittermeieri* was encountered only once during the transect walks. The presence of the small-bodied species, *Aotus nigriceps*, *Plecturocebus bernhardi* and *Mico nigriceps*, was only detected opportunistically, during non-survey fieldwork. These species were also recorded only once during the study. *Aotus nigriceps* has nocturnal habits and the other two species seem to use only the periphery of the study area, which was sampled less systematically during surveys. We thus confirmed the full inventory of primate species expected for this region, on the right margin of the Ji-Paraná River (see Miranda-Ribeiro, 1914; de Vivo, 1985; Iwanaga and Ferrari, 2001). Compared with the previous study of Iwanaga and Ferrari (2001) at Fazenda Mariana, approximately 50 km west of the present study site (Fig. 1), one more species