



RESEARCH PROJECT

Diet & behavior of reintroduced black-faced spider monkeys (*Ateles chamek*) in Tambopata, Peru

Anna Gerritse
Kawsay Biological Station

Wageningen University and Research
Forest Ecology and Management Group

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Introduction

The absence of large primates caused by defaunation can affect the structural composition of tropical forests. This is primarily due to reduced regeneration of plant species that rely on them for the dispersal of seeds (Nuñez-Iturri & Howe, 2007). Spider monkeys (*Ateles* spp.) are large-bodied, frugivorous primates known to be effective seed dispersers (Chaves et al., 2011; Dew, 2008; Hawes & Peres, 2014; Link & Di Fiore, 2006). They play a particularly significant role in the dispersal of tree species with large seeds, which only a few animal species are able to handle and swallow (Dew, 2008). In addition, seeds defecated by spider monkeys have been shown to have higher germination rates than control seeds (Chaves et al., 2011).

Due to increasing anthropogenic activities, the black-faced spider monkey (*Ateles chamek*) experienced a local extinction along the right bank of the lower Madre de Dios River, part of the buffer zone of the Tambopata National Reserve in the Peruvian Amazon (Bello Santa Cruz, 2018). Their disappearance from the area is estimated to have occurred between 1980 and 1990 (Pottie et al., 2021; Rosin & Swamy, 2013). In the Madre de Dios region, defaunation of large primates such as spider monkeys has been demonstrated to alter the spatial structure of plant communities. This is because reduced seed dispersal leads to the spatial clustering of recruiting trees (Bagchi et al., 2018).

In response to the loss of biodiversity attributed to anthropogenic pressures in this region, the Peruvian government established the Tambopata National Reserve in 2000 (Pottie et al., 2021). Since 2010, various groups of *A. chamek* have been reintroduced into the Tambopata National Reserve, as this was considered a feasible conservation strategy. All of these individuals had a prior history as a pet and have undergone an extensive rehabilitation process at the Taricaya Rescue Centre (Bello Santa Cruz, 2018; Pottie et al., 2021). This process includes medical treatment, socialization with conspecifics and rewilding training. While the duration of their stay varies based on each individual's condition and progress, it usually takes several years before they are ready for release into the wild. In the final stage, the monkeys are housed in an enclosure with the same conspecifics that will accompany them when they are released (Bello, personal communication).

Post-reintroduction establishment success is dependent on several factors, including the hours of human presence during the first three months and the presence of an already established group (Pottie et al., 2021). Individuals also vary in their capacity to adapt to their new environment, depending on their past experiences and personality traits. Yet, within the first month after release, most begin exhibiting behavioral adaptations (Bello Santa Cruz, 2018).

Currently, two groups of reintroduced *A. chamek* reside in the Tambopata National reserve and its buffer zone. One group consists of individuals reintroduced in 2011, 2013 and 2014, and is now considered fully adapted to the wild (Bello Santa Cruz, 2018; Pottie et al., 2021). The other group is still undergoing the process of adaptation at the time of writing. This group comprises four females that have first been released in 2022 and two females released in December 2023, who were the focus of this study. While their history before arriving at the research center remains unknown, one arrived as an infant and one as an adult. The latter is known to have experienced two pregnancies prior to her reintroduction.

Drawing insights from each reintroduction is crucial for informing future reintroduction efforts. The aim of this study was to assess the habitat use, strata use, behavior and diet of two females of *A. chamek* during their first month of adaptation to the wild. We evaluated their progress to determine if there was any early convergence toward wild monkey behavior. While dietary composition was studied in previously reintroduced groups (Bello Santa Cruz, 2018), this was the first study to also record the duration of feeding on each item, thereby providing more accurate insights. Assessing whether their diet gradually aligns more closely with that of wild individuals over time is crucial in ascertaining whether reintroduced monkeys will reclaim their role as seed dispersers in these forests.

We expected to see progress in the strata use and dietary preferences of the reintroduced individuals towards the end of the observation period, more closely resembling those of wild groups.

Furthermore, we explored whether differences in the monkeys' conditions prior to release affected their ability to adapt to their new environment. Considering their different age and past experiences, we anticipated that the adaptation process of the two individuals examined would differ. Insights into the factors that determine an individual's success at adapting can help refine the selection of suitable individuals for future reintroduction programs.

Methodology

Study site

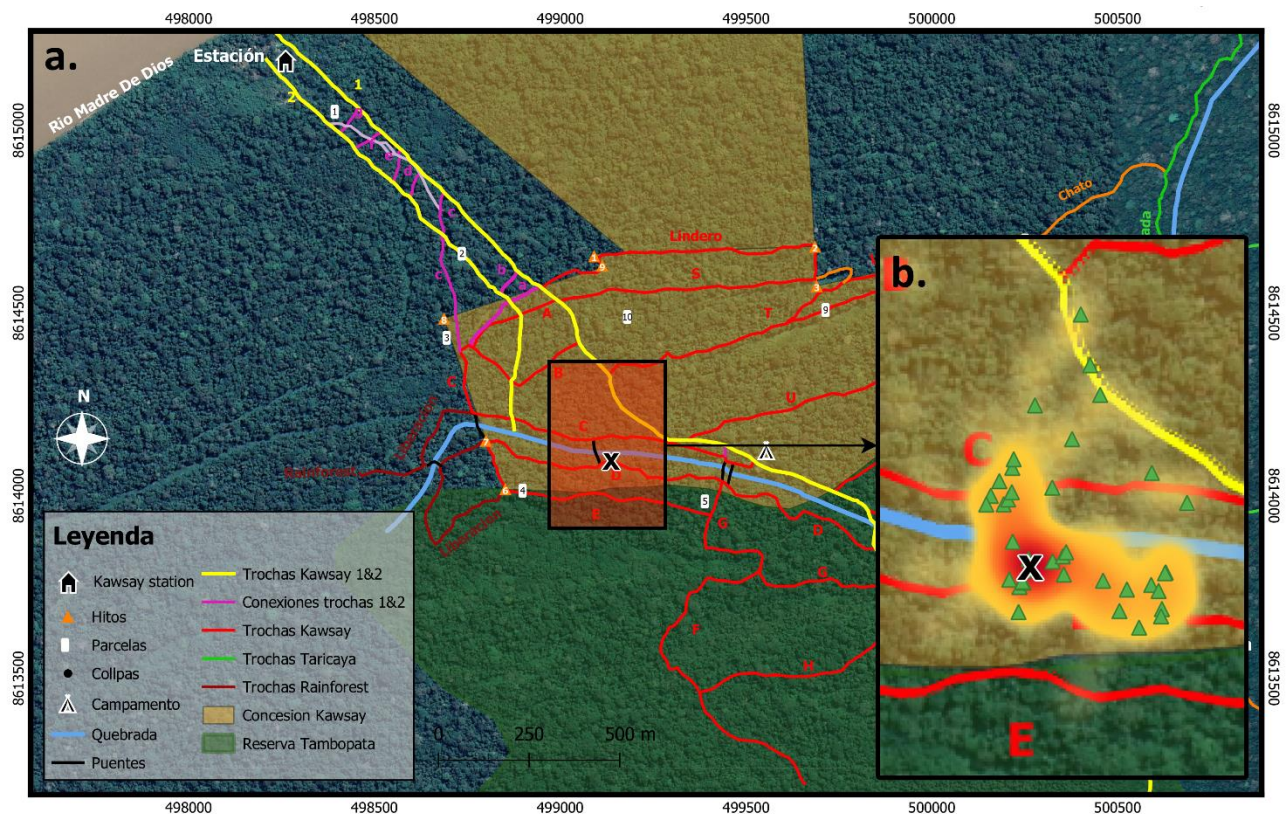


Figure 1. (a) Map of the Kawsay concession, with the study area highlighted in a red rectangle. The 'X' marks the house where the observers stayed, located next to the release site **(b)** Enlarged map showing the habitat range of Paola and Navi, with trees from which they consumed fruits indicated by green triangles.

The research was conducted within the the Kawsay Biological Station concession, located in the buffer zone of the Tambopata National Reserve in Madre de Dios, Peru. Figure 1a shows a map of the concession and its trails, with the study area highlighted in red. The release site was located inside the study area, next to a recently constructed bridge and house where the observers stayed.

According to the Holdridge life zones, the predominant vegetation type is seasonally flooded, primary, subtropical, wet forest (Holdridge, 1967). The average annual precipitation is 2387 mm, with an average relative humidity of 83%. The annual mean temperature is 26.5 C°. The climate is characterized by strong seasonality with a rainy season from November to April and a dry season from May to October (Azovskaja, 2020).

Study subjects

Two female individuals of *A. chamek*, named Navi and Paola, were studied. Navi arrived at the Taricaya Rescue Center on November 30, 2020 as an infant, while Paola arrived on November 5, 2020 as an adult. During her time in the center, Paola experienced two pregnancies, with her most recent infant sadly dying shortly before her release. Both were released on December 28th, along with two other individuals. The male, Darwin, disappeared almost immediately after the release and was not found again. The fourth individual, a female named Kuruba, had already spent 1.5 years in the forest previously and was therefore not the focus of this study.

On January 3rd, three additional individuals were released. These monkeys had already been in the forest since April 2022, along with Kuruba. However, they were recaptured due to excessive contact with humans and staying too close to the research station. After staying for about a month at the Taricaya Rescue Center, they were re-released further away from the research station to join Navi, Paola and Kuruba. Thus, for most of the study period, the monkeys resided in a group of six female individuals.

Data collection

Navi and Paola were observed for just over a month, from December 29th until February 2nd. Observation days started at dawn (6 am) and ended at dusk (6 pm). On some days, depending on the availability of observers, we took 2-hour breaks. These breaks were scheduled at different times each day to ensure effective days with an even distribution of observation hours across each part of the day. In total, this amounted to 338 hours of observation. Considering the periods that they were out of sight, Navi was observed for 306 hours and Paola for 293 hours.

Behavioral data was collected through focal sampling, with behavior recorded every 5 minutes. Four categories were used: traveling, feeding, resting and 'other', encompassing behaviors such as vocalizing, playing and grooming. We tried to observe Navi and Paola simultaneously for most of the time but when only one focal individual could be observed at a time, the other was categorized as 'out of sight'. In addition, the stratum at which the monkeys resided was noted every 5 minutes, categorized as forest floor (<2m), understory (<15m), canopy (>15m) and emergent layer (>30m). Every half hour the GPS location of the monkeys was logged in a Garmin GPS device to document their habitat range.

Data on the diet of the monkeys was collected continuously. Upon the initiation of feeding by an individual, the time at which they were observed engaging in feeding behavior was recorded. The plant items being consumed were documented and categorized as fruits (F), flowers (f), seeds (S), leaves (L), other (O) or a combination thereof. Additionally, it was indicated whether seeds were ingested. For fruits, it was noted whether the fruit was ripe or unripe. The growth forms of the plants being consumed were classified as trees (T), shrubs (S), palms (P), lianas (L), epiphytes (E), or hemi-epiphytes (H). If immediate identification in the field was possible, the genus and species of plant were noted. When the focal animal stopped feeding on components of the same plant, the time was noted, along with any noteworthy observations.

The mobile application 'Avenza Maps' was used to log the GPS coordinates of the trees where the monkeys consumed fruits within the map of the Kawsay concession. Each feeding tree received a distinct code, and in the field, they were marked with a red ribbon bearing the respective code. This facilitated the identification of trees that were revisited by the monkeys, simplifying recognition during subsequent observations. Photographs were taken of the feeding tree, capturing the fruits, leaves and bark. If identification in the field was not possible, plant species were identified in the field station using collected fruits, flowers and seeds, along with these photographs. A regional

expert that worked on phenological studies in the concession for four years, was consulted to assist with the identification.

Data analysis

The GPS coordinates from the Garmin device, documenting the monkeys' location every half hour, were used to create a habitat range map in QGIS. The GPS coordinates of the feeding trees collected in Avenza maps were overlaid onto the map. By outlining an area encompassing all GPS points, the total habitat area was calculated in hectares.

Activity budgets were determined by the percentage of time dedicated to each activity, calculated using the following formula:

$$\text{Percentage of activity} = \left(\frac{\text{Number of recording of activity}}{\text{Total number of recordings}} \right) \times 100$$

Strata use was calculated using a similar formula, with the numerator representing the number of recordings in a specific forest stratum.

Diet proportions were calculated using the following formula:

$$\text{Percentage of diet} = \left(\frac{\text{Time feeding on } x}{\text{Total time feeding}} \right) \times 100$$

In this formula, x could either represent the type of item eaten (fruits, leaves, other), or a plant family or species.

To examine if the diet and strata use changed over time, we divided the observation period into three roughly equal segments based on hours of observation. The observations hours were calculated by counting the number of observations per hour, excluding the times when a monkey was out of sight. The resulting periods were: December 29 to January 7 (96 observation hours for Paola and 99 for Navi), January 8 to January 22 (96 observation hours for Paola and 106 for Navi), and January 23 to February 2 (89 observation hours for Paola, and 95 for Navi).

Results

Habitat range

The habitat range of Navi and Paola was 6.26 ha (Fig 1b). Most of their GPS locations were recorded around the house where the observers stayed. Together, Navi and Paola were observed feeding from 35 different fruiting trees.

Behavior

Navi's behavior was recorded 3630 times. Resting was the most frequently observed behavior, with 1610 recordings, comprising 44.4% of the total (Table 1). This was followed by traveling, which accounted for 1161 recordings (32%), other behaviors with 437 recordings (12%), and feeding with 422 recordings (11.6%).

Paola's behavior was recorded 3404 times. Resting was also her most frequent behavior with 1823 recordings, comprising 53.6% of the total (Table 1). Traveling was the second most common behavior with 1042 recordings (30.6%), followed by other behaviors with 274 recordings (8%) and feeding with 265 recordings (7.8%).

Table 1. Activity budgets of Navi and Paola, a wild group in Bolivia, and prior reintroduced groups.

Activity	Navi	Paola	Wild group, Bolivia, January*	Prior reintroductions, wet season°
% Feeding	11.6	7.8	13	16.2
% Traveling	32	30.6	36	42.3
% Resting	44.4	53.6	43	40
% Other	12	8	8	1.5

Wallace, 2005*; Bello Santa Cruz, 2018°

Strata use

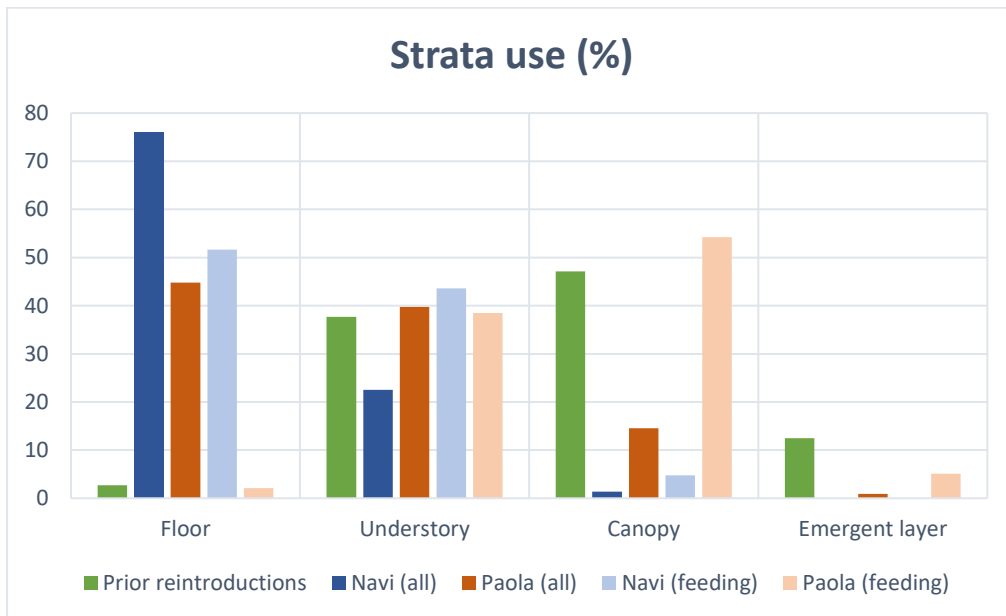


Figure 2. Strata use. Strata use of Navi and Paola, overall and during feeding, and that of previously reintroduced groups that were also released in the wet season; derived from Bello Santa Cruz, 2018.

Navi and Paola exhibited different patterns in their use of forest strata (Fig. 2). Navi spent 76.1% of her time on the forest floor, 22.5% in the understory, and 1.4% the canopy. In contrast, Paola spent 44.8% of her time on the forest floor, 39.6% in the understory (39.6%), 14.7% in the canopy, and 0.91% in the emergent layer.

The differences in their feeding habits across these strata were even more pronounced. Navi primarily sourced her food from the forest floor, amounting to 51.7% of her feeding time. She also fed in the understory for 43.9% of time, while she only fed in the canopy for 4.8% of time. In contrast, Paola mainly fed in the understory (54.4%) and the canopy (38.5%), with only 5.1% of her feeding time on the forest floor. Additionally, Paola was observed occasionally to feed in the emergent layer, accounting for 2.1% of her feeding time.

The use of different strata during feeding varied over the observation period (Appendix, Fig. 1). While Navi sourced food from the forest floor for 66% of time in the first period, this decreased to 32.4% in the last period. Conversely, her use of both the canopy and understory increased, from 31.3% to 60.3% and 2.6% to 7.3% respectively. For Paola there was no clear trend. Her use of the canopy fluctuated, going from 31.3% to 47.3%, and then down to 33% over the three periods. Additionally, she used the emergent layer only during the second period.

Dietary composition

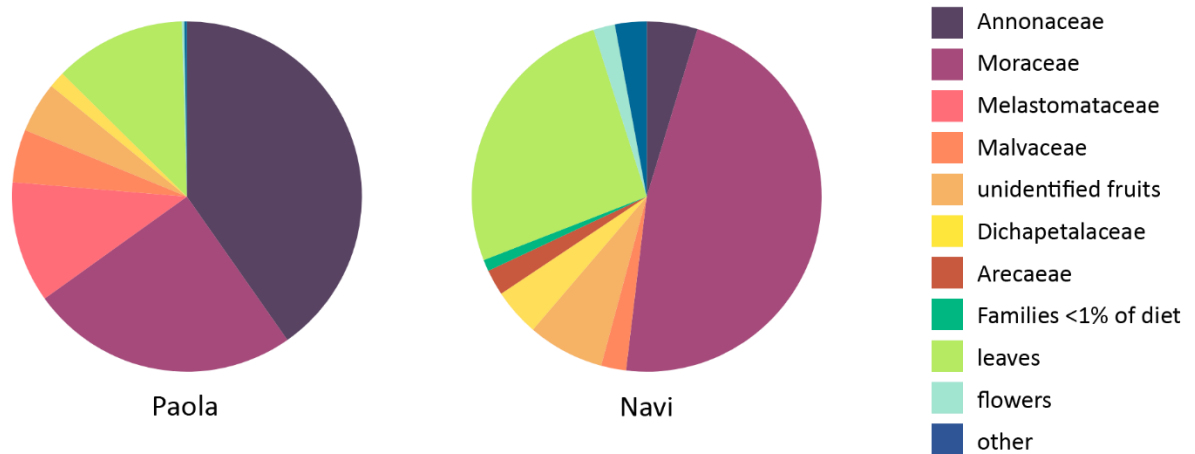


Figure 3. Dietary composition of Paola and Navi over the complete study period.

Navi's diet consisted of 69.1% fruits, 25.98% leaf material, 2% flowers and flower buds, and 2.92% other items (Fig. 3). The 'other' category includes observations of her consuming the bark of a fallen tree and eating termites. Navi was observed consuming fruits from nine different plant families. The dominant family was Moraceae, accounting for 47.19% of her total feeding time, followed by Annonaceae (4.69%) and Dichapetalaceae (4.38%). Other families included Arecaeae, Malvaceae, Melastomataceae, Violaceae, Salicaceae, and Polygonaceae. She was recorded consuming fruits from 27 different trees. We were able to identify most of these trees to either species or genus level, with two remaining unidentified, accounting for 7.07% of her total feeding time. Overall, she was observed eating from 16 different plant species (Table 2). The most consumed were *Sorocea pileata*, accounting for 20.29% of her total feeding time, followed by *Perebea tessmannii* (14.30%), *Ficus* sp. 1 (11.30%), and *Tapura peruviana* (4.38%).

Paola's diet consisted of 87.4% fruit, 12.14% leaf material, 0.23% flowers and flower buds, and 0.23% other components (Fig. 3). Paola was observed consuming fruits from five different plant families. The dominant family was Annonaceae, accounting for 46.06% of her total feeding time, followed by Moraceae (28.44%) and Melastomataceae (12.82%) and Malvaceae (5.61%) and Dichapetalaceae (1.74%). She was recorded consuming fruits from 23 different trees. We were able to identify most of these trees to either species or genus level, with only three remaining completely unidentified, accounting for 5.34% of her total feeding time. She was observed eating from 10 different tree species (Table 2). The species she ate the most were *Oxandra* sp. (26.84%), *Sorocea pileata* (19.49%), *Ruizodendron ovale* (19.23%), an unidentified species from the family of Melastomataceae (12.82%), and *Perebea tessmannii* (7.21%).

The average time spent feeding on fruit items differed between the two monkeys. During observation, Navi spent an average of 4 minutes and 48 seconds feeding on a fruit item, whereas Paola spent 7 minutes and 31 seconds, suggesting that Navi 'tried out' fruits more often, while Paola exhibited a stronger preference. Their feeding times were more comparable while feeding on leaves: both spent an average of approximately 3 minutes and 20 seconds feeding on leaf material.

Table 2. Tree species with fruits in the diets of Navi and Paola and the percentage of time they spent feeding on each.

Diet Navi		
Species	Family	% time feeding
<i>Sorocea pileata</i>	Moraceae	29.37%
<i>Perebea tessmannii</i>	Moraceae	20.69%
Ficus sp. 1	Moraceae	16.35%
<i>Tapura peruviana</i>	Dichapetalaceae	6.34%
<i>Ruizodendron ovale</i>	Annonaceae	3.67%
Oxandra sp. 1	Annonaceae	3.11%
<i>Matisia malacocalyx</i>	Malvaceae	2.45%
Ficus sp. 2	Moraceae	1.89%
<i>Astrocaryum murumuru</i>	Arecaceae	1.45%
<i>Socratea exorrhiza</i>	Arecaceae	1.33%
<i>Theobroma cacao</i>	Malvaceae	0.89%
Melastomataceae (sp. 1)	Melastomataceae	0.67%
Oenocarpus sp. 1	Arecaceae	0.67%
<i>Leonia crassa</i>	Violaceae	0.56%
Casearia sp.1	Salicaceae	0.22%
<i>Coccoloba peruviana</i>	Polygonaceae	0.11%
unidentified		10.23%

Diet Paola		
Species	Family	% time feeding
Oxandra sp. 1	Annonaceae	26.84%
<i>Sorocea pileata</i>	Moraceae	19.49%
<i>Ruizodendron ovale</i>	Annonaceae	19.23%
Melastomataceae (sp. 1)	Melastomataceae	12.82%
<i>Perebea tessmannii</i>	Moraceae	7.21%
<i>Theobroma cacao</i>	Malvaceae	3.74%
<i>Matisia malacocalyx</i>	Malvaceae	1.87%
<i>Tapura peruviana</i>	Dichapetalaceae	1.74%
Ficus sp. 2	Moraceae	1.20%
Ficus sp. 1	Moraceae	0.53%
unidentified		5.34%

Dietary composition over time

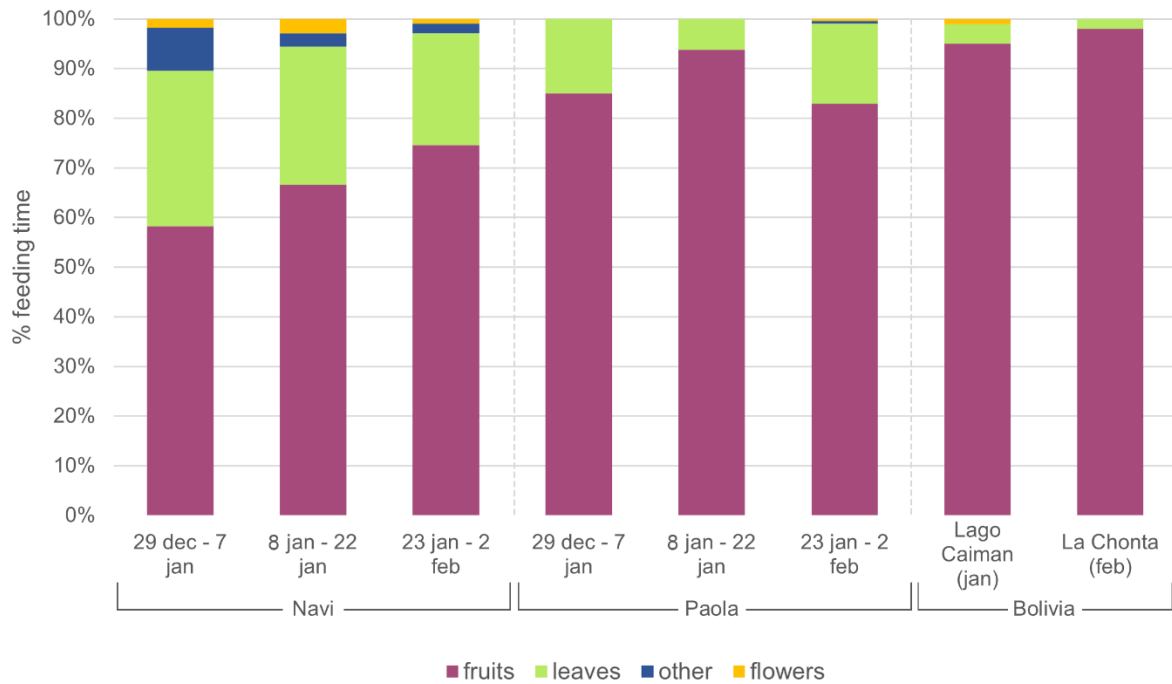


Figure 4. Dietary composition of Navi and Paola across three periods, each encompassing a similar amount of observation hours, and the diet of two wild populations in Bolivia around the same period.

The diet of both monkeys changed over the time they spent in the forest (Fig 4). It is important to note, though, that during the first observation period, they were provided with additional food. The proportion of leaves in Navi’s diet decreased from 31.3% in the first observation period to 22.5% in the last. Similarly, the proportion of ‘other’ items, such as termites or bark, decreased from 8.7% to 1.9%. Conversely, the proportion of fruits in her diet increased from 58.3% to 74.6%.

For Paola, there was no clear trend. In the first period leaves comprised 15% of her diet. This decreased to 6.2% in the second period but increased again in the final period to 16.2%. Her proportion of fruits changed correspondingly, increasing in the second period, but decreasing again in the third.

Discussion

In this study, the diet and behavior of two reintroduced female individuals of *A. chamek* were assessed. The main goals were to determine if the monkeys showed any early signs of convergence toward wild behavior and to evaluate whether differences in their pre-release conditions may affect their ability to adapt to the new environment. We collected data on habitat range, behavior, strata use, and diet. We expected to see progress in the strata use and dietary preferences of the reintroduced individuals towards the end of the observation period, more closely resembling those of wild groups. Secondly, we anticipated that the adaptation process of the individuals would differ, considering their different age and experiences.

Habitat range

The habitat range of monkeys of the *Ateles* genus commonly spans 95-390 hectares in wild groups inhabiting continuous forest (Asensio et al., 2012; Chapman, 1988; Wallace, 2008). This variability can be attributed to fruit availability (Wallace, 2008). Data is available on two previously reintroduced groups of *A. chamek* that were released in the wet season, one observed from November 2011 to February 2012, and the other from October 2014 to December 2014 (Bello Santa Cruz, 2018). In the first month after release, these groups used habitat areas of 32.74 ha and 21.72 ha, respectively, while their usage area decreased in the following months (Bello Santa Cruz, 2018). They were found to explore more of the forest in the first stage, while afterwards their movements decreased, and they concentrated their area near the camp zone.

In contrast, Navi's and Paola's habitat range in the first month did not exceed 6.26 ha, concentrated around the observers' house (Fig 1b). Notably, the previously reintroduced groups also included males, whereas Paola and Navi's group did not. In spider monkeys, individuals with high centrality in social networks play significant roles in leading collective foraging movements. Males are followed more frequently to new food patches due to their greater knowledge and larger ranging areas (Palacios-Romo et al., 2019). Thus, the absence of males may have limited their exploratory behaviour.

Nevertheless, Paola occasionally followed the other monkeys who had spent more time in the forest. However, she often followed them only to a certain extent before returning to the camp. This may be because she was still building confidence and familiarity with the group, as they were not enclosed together in the rescue center.

The difference in habitat use may also be partly explained by Navi's considerable reliance on human presence. Post-release human presence can limit spider monkeys' exploration of the environment (Trayford & Farmer, 2012). However, past reintroduction efforts have revealed that human presence in the initial month positively impacts survival rates (Pottie et al., 2021). Hence, current reintroduction strategies maintain human presence during the initial phase. After the first evaluation period, the frequency of human presence is gradually reduced (Bello Santa Cruz, 2018).

Behavior

Spider monkey activity budgets vary seasonally, likely due to changes in fruit availability (Nunes, 1995; Wallace, 2005). Monkeys spend less time feeding when the dominant fruit species in their diet has a higher mass (Wallace, 2005). Therefore, it is most appropriate to compare the activity budget of Paola and Navi to those of other *A. chamek* groups observed in the same month. In January, Paola and Navi's activity budgets were quite similar to those of a wild group in Bolivia, with resting being their most common behavior, followed by traveling, feeding and other behavior (Table 1).

When taking the average of the two previously reintroduced groups, traveling was their most common behavior (42.3%), followed closely by resting (40%), contrasting with Navi and Paola (Bello Santa Cruz, 2018). Also, their feeding time was slightly higher (16.2%) as compared to 11.6% and 7.8% for Navi and Paola, respectively. This small difference in activity patterns could be attributed to the broader data scope for these groups, not solely limited to the month of January. For instance, resting time was found to decrease through the wet season, while feeding time increases (Nunes, 1995).

Another notable difference was that Navi and Paola exhibited more 'other' behaviors such as vocalizing, grooming and playing (12% and 8%, respectively), compared to the previously reintroduced groups (1.5%), aligning them more closely with the wild group in Bolivia. This could indicate that Navi and Paola displayed more social behaviors, either towards other monkeys or

humans. However, this discrepancy might also be attributed to different observers, with those observing the previously released groups being more cautious in categorizing behaviors as 'other'.

Strata use

Monkeys of the *Ateles* genus prefer using the higher strata of the forest like the canopy and the emergent layer. For instance, in a study of *A. paniscus* it was observed that the monkeys rarely entered the understory and never descended below 12 meters (van Roosmalen, 1985). Similarly, in Costa Rica, *A. geoffroyi* was observed below 9 meters for only 6.92% of time, and there was just one sighting (0.12%) on the ground. A recent study in the Manu Biosphere Reserve in Peru showed that *A. chamek* preferred strata higher than 12 meters (Mendoza-Soto et al., 2024). This preference is likely due to several factors, including the high abundance of fruits in the upper forest strata, and the reduced risk of encountering ground predators, enhancing their safety (Wallace, 2008).

Reintroduced monkeys of *A. chamek* exhibit different behavior initially. During their acclimation period, they spend considerable time in the understory (<15m) and even on the forest floor (Bello Santa Cruz, 2018). This was also the case for Navi and Paola (Fig 2). However, the strata use of previously reintroduced groups aligned closer with that of wild monkeys. The previously reintroduced groups released in the wet season spent most of their time in the canopy (61.6% and 60.9%, respectively) (Bello Santa Cruz, 2018).

It is logical that Navi and Paola spent more time in the lower forest strata, as the two earlier groups were observed for several months longer, allowing them to demonstrate more adaptation toward wild monkey behavior. However, these groups spent minimal time on the forest floor (0% and 0.5%) while Navi and Paola spent substantial portions of their time there (76.1% and 44.8%, respectively; see Fig 2). This might suggest that earlier groups were better prepared or more suited for reintroduction. Again, the absence of a male in their group may have limited their exploratory behavior, including vertical movement. In addition, their tendency to remain near humans may indicate differences in their treatment at the Taricaya Rescue Center as compared to the earlier groups, potentially resulting in an overreliance on human interaction.

Notably, there were clear behavioral differences between Paola and Navi. Navi spent significantly more time on the forest floor compared to Paola, both overall and specifically during feeding (Fig 2). Paola often followed the other monkeys to feed in the higher forest strata. In contrast, Navi seemed primarily driven by her desire to always remain in proximity to humans. Navi sourced the majority of fruits she consumed from the forest floor, while Paola almost never did. Furthermore, Paola was even observed feeding in the emergent layer (>30 m) a couple of times, indicating her increased confidence in climbing high into the trees. There appeared to be a slight pattern of improvement for Navi though; in the last observation period, her use of the understory and canopy increased to the expense of her time spent on the forest floor (Appendix, Fig. 1). For Paola, there was no clear trend over time.

Diet

Species from the *Ateles* genus are morphologically adapted to a frugivorous diet, with characteristics such as large front teeth, while their postcanine teeth and jaws are relatively small. In addition, they possess long limbs that enable them to forage effectively in patchy fruit resources (Rosenberger & Strier, 1989). Moreover, their digestive system has a limited capacity to process large amounts of folivorous material (Rosenberger & Strier, 1989).

However, since high energy resources like fruits are not consistently abundant in the forest, *Ateles* supplement their diet with other food items, thereby displaying an energy maximizing foraging strategy (Nunes, 1995; Rosenberger & Strier, 1989). Consequently, during the dry season when fruit

availability is reduced, the proportion of leaves in the diet increases. In addition, they diversify their diet by consuming other items such as flowers, insects and tree bark (Castellanos, 1995; Chapman, 1987; McFarland Symington, 1988a; van Roosmalen, 1985).

In contrast, in the wet season the consumption of leaves is expected to be very limited. In the diet of two wild groups in Bolivia, the overall proportion of fruits in the diet was 85.8% and 82%. In January and February specifically, the proportion of fruits in the diet was even higher, about 95% for both groups (Felton et al., 2009; Wallace, 2005). For Navi and Paola, however, this proportion was notably smaller (Fig. 3; 69.1% and 87.4% respectively). Navi even demonstrated a dietary pattern resembling that of wild monkeys during the dry season, with high consumption of leaves and 'other' components such as bark and termites. She exhibited a lot of exploratory behavior, often trying out various food items without displaying a strong preference.

In both wild Bolivian groups, Moraceae was the most important family, representing the highest number of species in the monkeys' diet, and dominating in terms of feeding time (Felton et al., 2009; Wallace, 2005). This species was also important in the diet of previously reintroduced groups (Bello Santa Cruz, 2018). For both Navi and Paola, most species in their diet were also from the Moraceae family. For Navi, Moraceae accounted for 47.2% of her feeding time, while for Paola it was the second most important family after Annonaceae, comprising 28.44% of her feeding time (Fig. 3).

The diet of the wild group in Lago Caiman, Bolivia was dominated by *Spondias mombin* in January, making up more than 60% of the diet (Wallace, 2005). Interestingly, while this species was largely available within Navi and Paola's habitat range, there were no recordings of them feeding on it. This might be because *Spondias mombin* can reach heights up to 30 m (Adler & Kielinski, 2000) and both monkeys mainly fed on the forest floor and in the understory. Another possible explanation might be that the monkeys simply had not yet discovered any fruiting trees of this species. We often observed them visiting the same trees daily. As their habitat range expands, they might discover other species by explorative behavior and alter their dietary patterns accordingly.

Among the species recorded in the diet of Navi and Paola, some were also noted in the diet of previously reintroduced groups, such as *Sorocea pileata* and *Ruizodendron ovale* and species from the genera *Oxandra* and *Ficus*. However, *Perebea tessmanni*, *Tapura peruviana* and a species from the family Melastomataceae had not been previously recorded in the diet of the spider monkeys in the area (Bello Santa Cruz, 2018).

Interestingly, feeding behavior differed strongly between Navi and Paola. Navi showed extensive exploratory behavior, leading her to try out a wide variety of fruits from diverse families, whereas Paola demonstrated a distinct preference for specific species early on. This is reflected in their differing average feeding times on fruit items and the diversity of species in their diet. Furthermore, the proportion of leaves in the diet of Paola was much lower, and there was only one observation of her feeding on something different than fruits or leaves, more closely resembling the diet of wild monkeys. Navi's diet showed a notable increase in the proportion of fruits over time, aligning more with the wild monkey diet (Fig. 4). While Paola did not exhibit this trend, the proportion of fruits in her diet was still higher than Navi's at the end of the observation period. One month may have been too short for Paola to show further adaptation.

Individuals' suitability for reintroduction

Navi and Paola displayed notable differences in their behavior during the first month after release. Paola exhibited behavior more closely resembling that of wild monkeys, by feeding in higher forest strata and displaying greater dietary preferences than Navi. Navi's behavior, however, seemed more affected by her tendency to stay close to humans. She often exhibited behavior indicative of fear, seemingly seeking a maternal figure for reassurance. In addition, Paola seemed to be more

influenced by the presence of other monkeys that had acclimated to the forest for 1.5 years. She often followed their lead, expanding her habitat range and venturing into higher forest strata as a result.

These behavioral differences could be attributed to their experiences before entering the Taricaya rescue center and their treatment there prior to release. Notably, Paola entered the rescue center as an adult, whereas Navi arrived as an infant. In addition, Paola had already experienced multiple pregnancies before the release. This resulted in a difference in maturity at the time of their release in the forest.

After the study, Navi was returned to the rescue center upon being discovered in the city of Puerto Maldonado. She was probably captured for trading purposes, highlighting the unfortunate reality of individuals seeking monetary gain from such activities in the forest. However, given her tendency to roam on the ground and seek human contact, she likely became an easy target. At this stage of her life, she was not yet suitable for release. Nonetheless, Navi exhibited some improvement, offering promise for her potential to adapt more effectively to forest life in future reintroduction efforts as she matures.

Conclusion & recommendations

The timing of the reintroduction, in December, was well chosen. The abundance of fruit in the forest facilitated the monkeys' learning and exploration. By the end of the study period, Navi showed behaviours more closely resembling those of wild monkeys, such as increased use of the upper forest strata and a higher proportion of fruits in their diet. For Paola, there was no clear trend, but she started her adaptation process at a higher entry level.

The presence of other monkeys that had already acclimated to the forest for longer positively influenced adaptation, as observed in Paola, who expanded her habitat and strata usage following the other individuals. The presence of males in a group could enhance the adaptation process even more by promoting exploratory behavior. In this instance, the planned male companion was unfortunately lost immediately after the release. Nonetheless, this highlights the importance of male inclusion in future reintroductions.

Paola was better suited for reintroduction as compared to Navi. Their differing abilities to adapt may have been due to differences in maturity or possibly even personality traits. Thus, when selecting monkeys for release, it is important to assess their level of maturity beforehand. This assessment could involve observing their interactions with both humans and other monkeys at the Taricaya Rescue Center, specifically looking for behaviors indicative of fear or seeking reassurance. In addition, it is crucial to maintain a critical stance regarding the handling of monkeys at the rescue center. Navi's persistent desire to remain in proximity to humans implies that she may have been overly accustomed to human interaction during her stay there. The primary aim of the center should always be to prepare the monkeys for reintroduction as effectively as possible and encourage connections with other monkeys, while minimizing interaction with humans.

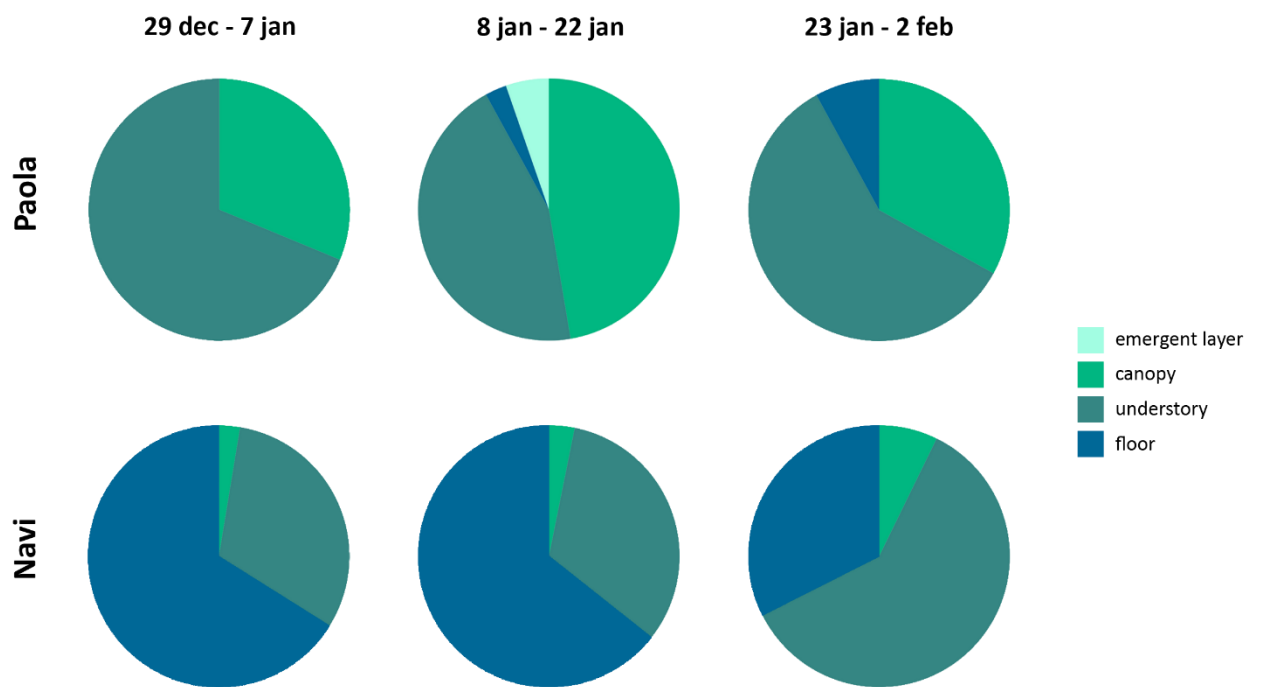
Thus, for future reintroduction efforts, factors to consider include ensuring the presence of a male, conducting assessments of the maturity of the individuals prior to the release, and minimizing interaction with humans at the rescue center.

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Appendix



Appendix, figure 1. Forest strata use of Paola and Navi during feeding across three different periods, each encompassing a similar amount of observation hours.