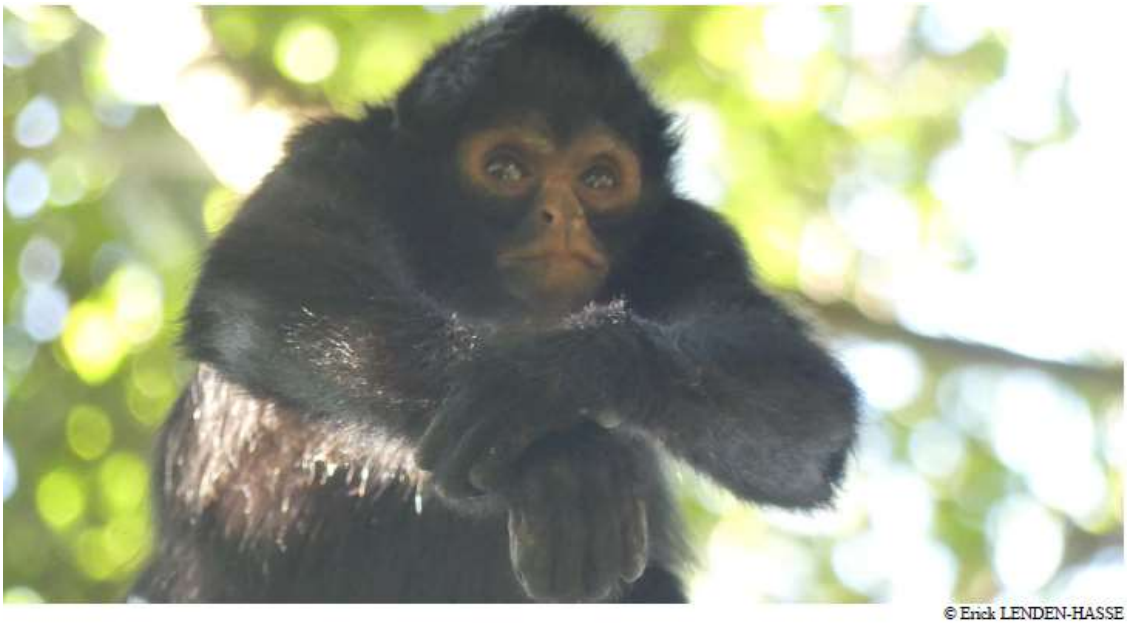
Rapport de stage de seconde année de master pour l'année universitaire 2018/2019
Master 2 BEE Biodiversité Écologie Évolution
Parcours ECIRE - Écologie de la Conservation - Ingénierie Écologique: Recherche et Expertise

Étude des variations de comportement et du régime alimentaire selon la saison et la catégorie d'individus chez un groupe de singe-araignée à tête noire (*Ateles chamek*) réintroduit

dans la zone d'amortissement de la Réserve de National de Tambopata – Pérou



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Erick LENDEN-HASSE
Encadrant: Raúl BELLO
Kawsay Biological Station – Puerto Maldonado – Pérou
Du 7 mars au 7 septembre 2019
Date de la soutenance : 27/09/2019

PRESENTATION OF THE HOSTING STRUCTURE

Kawsay is an NGO (Non Governmental Organization) located one hour by canoe from the city of Puerto Maldonado in the Madre de Dios region of Peru. This biological station of more than 200ha is located on the right bank of the Madre de Dios River and was founded in 2018 by Raul Bello Santa Cruz, the supervisor of this internship. Kawsay - which means life in the Quechua language - is located in the buffer zone of the Tambopata National Reserve, and aims to preserve the biodiversity of the Amazonian forest through education and research programs. This station, whose main stakes are biodiversity conservation, allows Peruvian and international students to learn and practice different methods to study and conserve biodiversity. The main project of this NGO focuses on the reintroduction of locally extinct black-headed spider monkeys (*Ateles chamek*), in partnership with Taricaya , an eco-reserve that has a rehabilitation centre for Peruvian wildlife. A monitoring of the reintroduced population started a year ago and allows the study of their behaviour, especially their diet for conservation purposes.

A study of the diversity of birds, amphibians, bats and other mammals is also being orchestrated, using different methodologies such as transects or through the study of videos and pictures from camera traps.

The association's base camp is equipped with electricity from solar energy, drinking water from groundwater and has no internet connection.

This place allows us to live in an international community where we learn from each other and share our knowledge about biodiversity and our culture.

ACKNOWLEDGE

I would like first to thank Raul Bello without whom this internship would not have been possible; thank you for the trust he has placed in me, for the knowledge he has shared with me and for allowing me to live this extraordinary experience in the Peruvian jungle. And above all, thank you for dedicating your life to the conservation of biodiversity.

Thank you to all the Taricaya team, especially to Rachel, Sam and Paula for their precious help, for their involvement in the reintroduction project and for their friendship.

Thanks to all the Peruvian students and international eco-volunteers, their wise advice and precious help in the field made this study possible. Thank you to each of them for all these moments.

I also want to thank Carmen Bessa Gomes for her advice and availability and Carole Gaber for her precious help.

SUMMARY

INTRODUCTION

General Context

In 2019, the IPBES (Intergovernmental Platform on Biodiversity and Ecosystem Services) draw up a report revealing the state of biodiversity. Written by 150 international experts, this report was presented at the world headquarters of UNESCO (United Nations Educational, Scientific and Cultural Organization) with the aim of contributing to the improvement of policies and actions in favour of biodiversity. The report describes nature declining at an unprecedented rate, with five causes identified: habitat destruction, invasive species, pollution, climate change and overexploitation of species. They are all anthropogenic in origin. Poor agricultural practices, land use change and overfishing are contributing to the acceleration of the extinction rate of species, which is already ten to one hundred times higher than the average over the last ten million years (IPBES, 2019).

A study published in the scientific journal Nature in 2016 showed through species distribution models that disturbances to the landscape and forests have contributed to the loss of biodiversity, with the greatest negative effects on species with high functional and conservation value. These results demonstrate an urgent need for policy interventions that go beyond maintaining forest cover to safeguard the hyper-diversity of tropical forest ecosystems (Barlow, 2016).

Ateles conservation

According to the International Union for the Conservation of Nature (IUCN), the current wild population of Ateles chamek has been considered "Endangered" since 2008 and belongs to Appendix II of the Washington Convention (CITES). Its distribution is concentrated in the Amazon basin and can be found in 3 countries; Bolivia, Brazil and Peru (Figure n°1, below). This species is considered a conservation issue in most of the natural protected areas where it occurs, but populations in these areas are declining due to human pressures. In particular, these monkeys may be hunted for their meat or to be sold as pets illegally, which usually involves at least the death of the mother and the resale of the juvenile when it survives. According to the Maestro Plan 2004-2008 for the Tambopata National Reserve in the Madre de Dios region of Peru, the spider monkey is considered a management priority for conservation due to its socio-cultural importance, as it can be considered a heritage species, especially in the jungle. Extinct in several localities despite its conservation status, the Tambopata National Reserve aims to re-establish viable populations where they are extinct and to ensure their safety.

Figure n°1: Distribution area of Ateles chamek

Ecological role

Among the Platthyrinhians, or New World monkeys, spider monkeys have the highest proportion of fruit in their diet. Moreover, they are also the ones using the highest strata of the forest. Spider monkeys are endochorial dispersers, they consume fruits from 349 species belonging to 29 families. However, they do not predate the seeds and don't swallow those from Arecaceae, whose size (up to 27mm wide) is too large. These seeds can occasionally be predated by woolly monkeys. When they defecate from the top of the canopy, the seeds are widely spread and can cover an area of up to 13m², thus reducing the chances of predation by rodents and peccaries (mammals), and limiting competition after germination. The average distance of dispersal by spider monkeys for a seed from the parental tree is 245m, with a range from 50 to 600 metres (Mittermeier, 2013).

Spider monkeys are the only known dispersal vector for a multitude of South American plants. Many animals rely on these plants for food, or for nesting. Spider monkeys are probably the most important dispersers of large fleshy seeds in the Amazon and even more so in other ecosystems where it is found. With this key ecological role and its sensitivity to hunting pressure, this threatened primate can be use as a neotropical forest indicator species, its absence resulting in a disturbed ecosystem (Dew, 2008).

Reintroduction Project

IUCN considers reintroduction as a way to re-establish a population when the species concerned has high conservation value or when reintroduction is an integral part of a management programme (IUCN, 2002 and 2013).

In the past, most primate reintroduction projects have been motivated by heritage reasons rather than the functional conservation value of the species, usually confiscated individuals were reintroduced to

avoid euthanasia (Cowlishaw, Dunbar, 2000). However, these practices were poorly organized and poorly documented (Wilson, Standley Price, 1994).

Two reintroduction projects have previously taken place for spider monkeys, in Panama and then in Costa Rica with the species Ateles geoffroyi. High mortality of reintroduced individuals was observed at the beginning of the programmes, then the surviving individuals, known as "founders", eventually developed behaviour similar to that of their wild counterparts and have reproduced until today to form a stable and genetically viable population (Milton, Hopkins, 2005).

In 2009, the Taricaya rehabilitation centre planned a programme to reintroduce several groups of Ateles chamek into the buffer zone of the Tambopata National Reserve, which was approved and officially recognized by the competent Peruvian authorities in 2012. The different groups reintroduced over the years have not always been as successful as expected and recaptures of individuals have been necessary, but today, this buffer zone of the reserve contains a stable population initially made up of previously captive individuals and to which several individuals born in the wild have been added. This has required a complex rehabilitation process that has been refined through years of experience and consistent post-release monitoring of the individuals concerned (Bello b, 2018).

The absence of large frugivorous mammals in primary forests has an impact on the regeneration of tree species that depend on them to disperse their large seeds. A decrease in abundance or even local extinction of these trees is the consequence (Swamys, 2013). Therefore, the spider monkey reintroduction project aims not only to re-establish a stable population of a locally extinct species, but also to allow a greater regeneration of local tree species. These are essential for the life cycle of other species and for the regeneration of the forest, especially in places that have been altered by human activities and are now protected.

Objectiv

Conservation issues for spider monkeys are related to their heritage and their functional role within the forest ecosystem. This is manifested in the actions of the Kawsay association, mainly through the mobilization of land to make them protected areas, as well as through the reintroduction of individuals. In this context, the missions proposed within the framework of the training course are the monitoring and collection of information on behavioural variations and food preferences of a group of individuals reintroduced from Ateles chamek. This information constitutes a resource for conservation missions as it helps to guide operational actions in reintroduction programmes. In addition, this data allows us to question several specific questions related to the behaviour of reintroduced individuals:

1. Is there a difference in the activity pattern of individuals between the wet and dry seasons?

2. How has the behaviour changed since the post-reintroduction period? And comparison with other wild populations.

3. Does the variation in behaviour vary according to the age and sex of the individuals?

4. Is there a difference in feeding behaviour between the dry and wet season?

MATERIALS AND METHODS

Study area

The study area is located in the south of the Madre de Dios River in the province of Tambopata. This area is within the Tambopata National Reserve and two concessions that are part of the buffer zone of this same reserve. The first concession is the Kawsay Biological Station for conservation purposes with an area of 178 ha, the second is the Taricaya Ecological Reserve with an area of 476 ha which is an ecotourism concession (Figure 2).

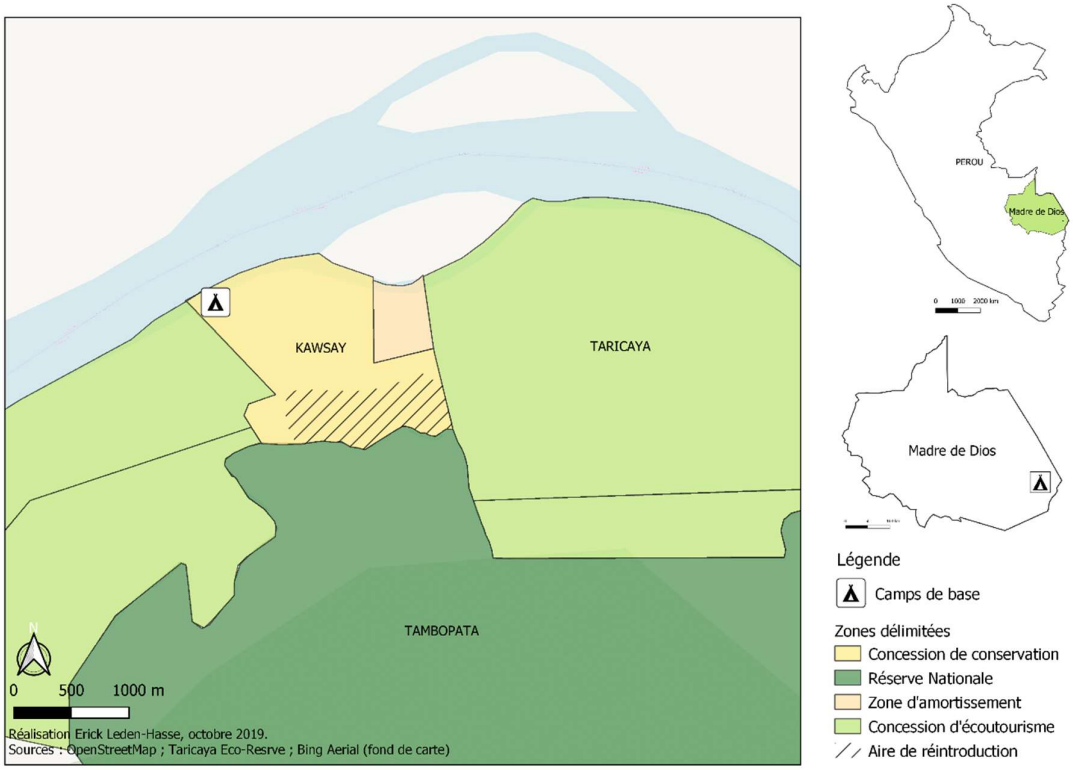

Figure 2: Map showing the location of the Kawsay Biological Station.

The study area is a Subtropical Humid Forest (bh-S: Bosque de Humedad Subtropical), this area is between 150 and 250 meters in altitude. The characteristic forest in this area is a Floodplain Alluvial Forest (Bai) found on flat land with depression in adjacent river areas (IRENA 2003b).

There are two seasons marked by a difference in precipitation; a dry season from May to October and a wet season from November to April. The average annual precipitation for this region is 2387 mm, the average annual relative humidity is 83% and the average annual temperature of the department is 26.5°C (SENAMHI, 2015).

Base Camp

The base camp is located on the banks of the Madre de Dios river in the Kawsay Biological Station, it is equipped with beds, a kitchen with fresh food, tables, chairs, electricity from solar energy, first aid equipment, binoculars, GPS, scientific books, decameters. This place is the starting point to look for groups of released monkeys in order to follow them and collect data. The search for the spider monkeys was usually carried out with a minimum of three people.

Characteristics *Ateles*

Monkeys of the family Atelidae are the largest of the New World monkeys, including spider monkeys (Ateles), howler monkeys (Alouatta), woolly monkeys (Lagothrix) and muriquis (Brachyteles). They have a prehensile tail that they use as a fifth limb to move around trees or to hang themselves. Their arms are proportionally long in relation to their bodies, they have an elongated metacarpus and a vestigial thumb on the forelimbs, make them use their hands as hooks. Their bodies are perfectly adapted to an arboreal lifestyle.

Spider monkeys are historically present in almost all the tropical forests of Central and South America where they can coexist with other species of Atelidae as they live in significantly different ecological niches. Spider monkeys use the uppermost part of the forest, mainly canopy and emergent branches, and have a predominantly frugivorous diet where, for example, howler monkeys are predominantly folivorous (Mittermeier, 2013).

Social composition

The social structure of spider monkeys is said to be fission-fusion like chimpanzees, these groups are made up of between 25 and 55 individuals and are subdivided into subgroups of varying size for varying lengths of time. This social structure seems to be an adaptation to optimize the costs and benefits of living in large groups (Lehman, Boesch, 2008). Often females travel in small groups with their offspring, these subdivisions are related to food availability, when food becomes abundant the subgroups merge. Males are philopatric while females disperse from their natal group once sexual maturity is reached. Relationships between males are very strong within a group because they have a high kinship rate where females only rarely share social moments or grooming. When dividing into subgroups, females will restrict themselves to a small territory where food is abundant while males will patrol and travel long distances to defend their territory from other males and access to food for females.

The densities of individuals per km² in Peruvian national parks are highly variable according to the hunting pressures and habitat loss exerted on spider monkeys populations by humans. In Manu National Park, densities have fluctuated between 25 and 49 individuals per km² over the years (White, 1986; Endo, 2010), while in the Pacaya Samiria National Reserve it is less than 1 (Aquino, Bodmer, 2006).

Reproduction

Spider monkeys reach sexual maturity between 4 and 5 years of age and the gestation period is 230 days, at the end of which the female gives birth to a single pup, although twin births have already been observed. Females often isolate themselves away from the group when they have offspring in order to avoid competition between males, as the latter may commit infanticides to reduce the latency time between two reproduction from more than 30 months to about 10 months. There is no strong seasonality for spider monkey's reproduction, but there is a lack of sexual intercourse during periods of low fruit abundance. Thus, those monkeys have a low reproduction rate, which has an impact on its conservation and populations need time to recover from the loss of individuals due to human activities (Ramos-Fernandez, Wallace, 2008).

Study Group

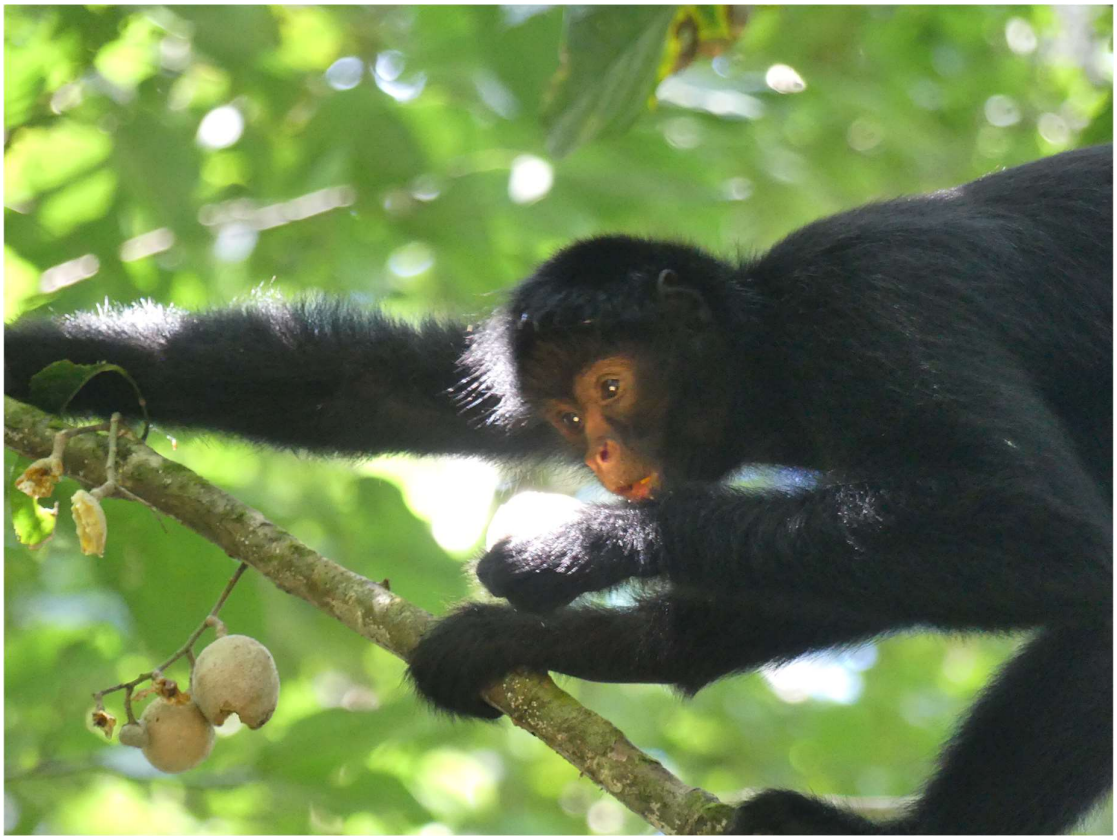

Figure n°3: Picture of an individual Ateles Chamek from this study © Erick Lenden-Hasse

The individuals followed for this study belong to different *Ateles chamek* reintroduction groups. A first group reintroduced in November 2011 now includes 7 individuals (plus an eighth exceptionally observed), several of which were born in the wild. The second group was reintroduced in October 2014 and now comprises 4 individuals (Table n°1). A third group was reintroduced in July 2019 also comprising 4 individuals. This study focuses on the behaviour of a reintroduced group of monkeys that has become self-sufficient. For this reason, the last group was not counted for this study, as the individuals are in a rehabilitation period. Due to the social composition of spider monkey : fission-fusion, the first two groups are sometimes together for varying periods of time. The third group remains on the fringe of these experience groups.

The three groups mentioned above are only those currently present in the wild, but other attempts to reintroduce groups of individuals have taken place in the past and have not always been successful. Some groups have disappeared and potentially migrated to the heart of the Tambopata Reserve to avoid conflicts with the first reintroduced group, others have had to be recaptured due to post-release behaviour deemed insufficient. Such behaviour corresponds to :

- Too much time spent moving around on the ground after a period of acclimatization, compared to the behaviour of wild individuals;

- Looking too much for human presence after a certain period of time;

- Falling from the top of the canopy, which can lead to injuries that prevent survival

- An attack by a ferocious harpyja (Harpia harpyja) resulting in the death of some individuals.

Group #	Name	Reintroduction date	Age group	Sex	Observation
1	Sambo	Nov - 2011	Adult	Male	
1	River	Nov - 2011	Adult	Female	
1	Abie	Nov - 2011	Adult	Female	
1	Wawa	Born Oct - 2013	Adult	Female	Born in the wild
2	Lucha	Oct – 2014	Adult	Female	
2	Lila	Oct – 2014	Adult	Female	Death Aug - 2018 fallen from tree
2	China	Oct – 2014	Adult	Female	Disappeared Jul - 2018
2	Gaïa	Born May - 2015	Juvenile	Female	Born in the wild
1	Aliah	Born Agu - 2016	Juvenile	Female	Born in the wild
2	Lola	Born Agu - 2016	Juvenile	Female	Born in the wild
1	Rambo	Born Dec - 2016	Juvenile	Male	Born in the wild
2	Chabelo	Born Apr - 2018	Juvenile	Male	Born in the wild
1	Rocoto	Born May - 2019	Infantile	Male	Born in the wild
1	Peru	Born Agu - 2013	Adult	Male	Présence aléatoire Né à l'état sauvage

Table n°1: Inventory of Ateles chamek individuals evaluated for this study

Individuals were studied according to their category, gender (male or female) and age group (juvenile or adult). An additional category was evaluated in the data collection, namely lactating females, which were distinguished from non-lactating females. However, this study does not examine the differences in behaviour between these two categories of females. This is due to the fact that among the low numbers (2 successive individuals over the year), one of the individuals had a behaviour that testified to its

reintroduction, notably the movements observed in the undergrowth linked to the presence of an observer. Data from lactating females are therefore added to the adult females (Table 2).

AM	AF	LF	JM	JF
Adult Male	Adult Female	Lactating Female	Juvenile Male	Juvenile Femelle

Table n°2 : Different categories of individuals used for this study

This group of individuals is studied in blocks of 2 months. During these 2 months, each category of individuals must be studied for each of the time slots of activity of these diurnal animals. Either between 6 am and 6 pm. For a period of 2 months, each of the 5 categories is studied for 12 hours, evenly distributed over the period of daily activity.

In order to locate the groups of primates, it is first necessary to walk for 30 minutes to reach the potential distribution area of the studied primates and then initiate a thorough search in the area where they were last observed. We emit calls at regular frequencies to which some individuals (such as Lucha, one of the females in the group) emit vocalisations in response. This allows us to locate them more easily, or it may direct the individuals in our direction.

Some individuals are equipped with radio collars using VHF telemetry but this is no longer used to locate individuals because the frequencies are confusing and have little effect.

The individuals were followed regularly and studied from May 2018 to August 2019 but for this study the data used are those between May 2018 and April 2019, which corresponds to one year of study, i.e. two seasons. Data collection is conducted between 6 am and 6 pm, with the number of hours of assessment of individuals depending on the need and availability of the assessors.

Activity pattern

The collection of behavioural data was carried out by direct observations of spider monkeys in the field using the "scan sampling" method developed by Altmann (1974). For this study an observer assesses one individual at a time and records behaviour for a defined time interval of 5 minutes. An ethogram, some categories of which are common to studies of animal behaviour, and adapted for the need to study certain taxa (Table n°3) (Appendix n°1).

Categories	Description	Activity
Feeding	When the animal consumes food, seeks food, wood	Feeding itself
Traveling	Displacement with the purpose of changing location, tree or branches t	Walking, Jumping, Climbing, Brachial displacemen
Resting	When an animal is motionless, sitting, sleeping and does not involve another activity or other	Sleeping, sitting

Social Interaction	Interaction between individuals, positive or negative	Games, Aggression, "grooming" delousing
Other	Any other type of behaviour not previously informed	Vocalising, interaction with the observer

Table n°3: Ethogram showing the different behaviours carried out by the group studied

Habitat Use

In order to study the use of the forest by the spider monkeys, we are interested in their movement along the vertical plane of the forest. This involves dividing the forest into 3 distinct strata, the understory from the ground surface to 15 metres, the canopy from 15 metres to 30 metres and the overstory layer include the upper 30 metres. (Figure n°4)

In order to collect the data, the same methodology was used as for the activity pattern, information on the position according to the vertical plane of the forest per individual every 5 minutes.

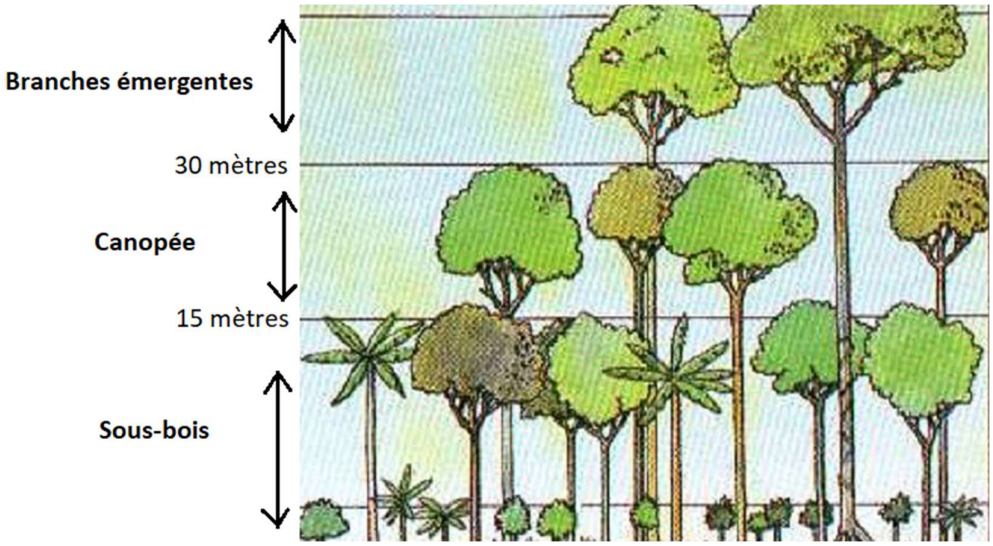

figure n°4: Illustration of the different strata of the forest

Eating behaviour

At the same time, the diet of the group of monkeys studied is collected Ad libitum (Altman, 1974). To do this, each food consumption event is recorded for the individual evaluated, taking into account the time of the beginning and end of the event, the type of food consumed (fruit, leaf, bark, other), the food carrier (tree, liana, epiphyte, other) and finally the stratum in which the individual studied is located when he consumes the food (undergrowth, canopy, emerging branches) (Appendix n°2). Samples of the food consumed are collected as well as leaves and fruits of the tree or liana. They are photographed and later identified using identification cards (Alvarez Loayza, 2013) (Figure No. 5).

Figure 5: Picture of fruit harvested for identification.

Analysis of the results

I) Data were analyzed by season (dry or wet), age (adult or juvenile) and sex (male or female). They were then ordered on Microsoft Excel and analyzed on Rstudio for statistical testing ("chisq.test" on Rstudio).

II) Data were analyzed by season (dry or wet), age (adult or juvenile) and sex (male or female). They were then ordered on Open Office 4.1.5 and analysed on RStudio for statistical testing.

To compare the data including 2 variables as dry season and wet season, the Mann-Whitney-Wilcoxon test ("wilcox.test" on RStudio) was used, it is a non-parametric test corresponding to a random sampling with no homogeneity of variances and whose values are not represented according to a normal distribution. In order to compare data comprising more than 2 variables, as is the case for the activity pattern or strata according to the vertical plane of the forest, the Kruskal Wallis test ("kruskal.test" on RStudio) is used.

RESULTS

Activity pattern

Over one year, or 6 sampling periods of 2 months, 360 hours of assessment were performed, which included 4350 scans for the activity pattern and 4350 scans for the occupied stratum. As explained, each of the five categories studied accounted for the same number of hours and therefore of scans. The data obtained between May 2018 and October 2018 correspond to the dry season while the data from November 2018 to April 2019 correspond to the wet season. For this study, only the data collected during the period March 2019 - April 2019 were collected by me. All observers have the same behavioural identification references. A full sampling period requires an actual field presence of one year, which is why earlier data were used in this study. Data were collected between May and August 2019 but have not been included here. In the same way, these data will be included in a collaboratively developed database to allow for a statistical study on a full sample.

The figure below represents the distribution of the different behaviours observed according to the season.

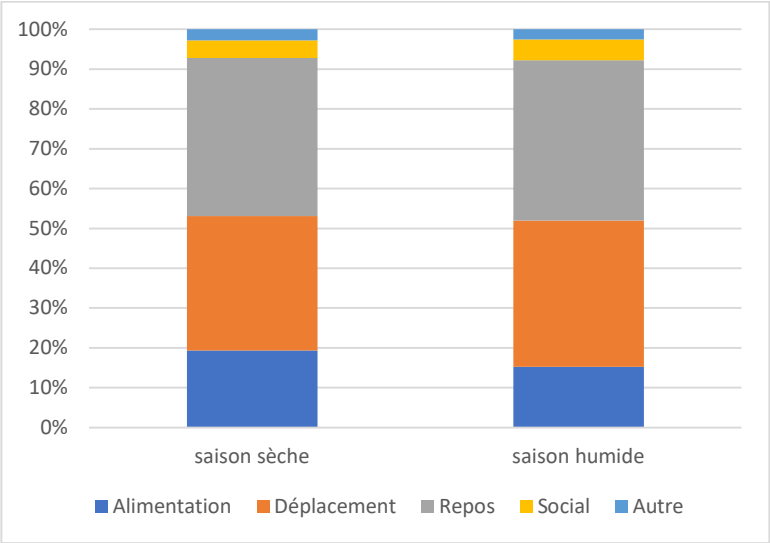

Figure n°6: Percentage representation of the activity pattern as a function of the season

% activity	Feeding	Travelling	Resting	Social Interaction	Other
Annual average for this study between MAY-2018 and APR-2019	17,3	36,8	40,2	4,8	2,7
This same group after reintroduction (8 weeks in 2011 and 8 weeks in 2014) (Bello, a, 2018)	16	39,6	43,2	/	1,2
Study on another group of *Ateles Chamek* in Bolivia (Wallace, 2001)	18,9	29,7	45,5	/	5,9

Table 4: Comparison of results with the same post-reintroduction population and with another wild population

It can be seen that on average the most frequent activity for the group studied is resting, around 40%, followed by travelling (36.8%), eating (17.3%), then social interaction (4.8%) and finally other activities (2.7%). These average values obtained over one year are very similar and follow the same trend as those obtained after the reintroduction of these same groups of individuals as well as that obtained by Wallace in 2001 with another group of chamek workshops in Bolivia.

I) There is a significant difference in the pattern of activity between the dry season (May 2018 - October 2018) and the wet season (November 2018 - April 2019) because according to the Khi-Deux test the p-value is strictly lower than 0.05 (X-squared=15,938; df=4; pvalue=0.003013).

II)

% d'activité	Feeding	Travelling	Resting	Social Intéraction	Other
Statistique du test W Mann-Whitney-Wilcoxon	137	83,5	120	82	138,5
p-value	0,3185	0,2366	0,7711	0,2116	0,2856

On the other hand, no significant difference is observed between the data obtained for the dry season (May 2018 - October 2018) and the wet season (November 2018 - April 2019) because, according to the non-parametric Mann-Whitney-Wilcoxon test, the p-value is strictly higher than 0.05 for each of the activities.

As for the activity pattern, below are presented the results in graph and table form for the use of the vertical stratum during the two seasons.

Use of the vertical strat

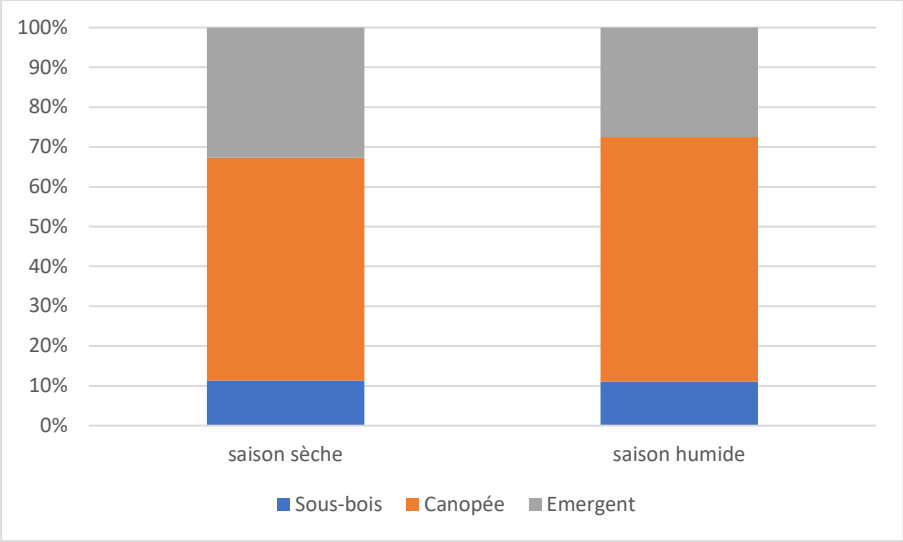

Figure n°7: Percentage representation of the occupied strat according to the season

% area use	Understory	Canopy	Overstory
Annual average for this study between MAY-2018 and AVR-2019	11,2	58,7	30,1
This same group after reintroduction (8 weeks in 2011 and 8 weeks in 2014) (Bello, a, 2018)	40,4	47,1	12,5

Table n°5: Comparison of results obtained with the same population in post-reintroduction

The values obtained for forest use in the vertical plane do not follow the same trend between the one-year study and the post-reintroduction study of the spider monkey groups. The percentage obtained for the time spent in the canopy is relatively similar, but the time spent in the understory is now much less significant, 11.2% compared to 40.4%, and the time spent above 30 metres is much higher in the recent study, 30.1% compared to 12.5% (Table 5).

I) There is a significant difference between the use of strata between the dry and wet season according to a Chi-Squared test (X-squared=15.519; df=2; p-value=0.0004267 > 0.001).

II)

% area use	Understory	Canopy	Overstory
Statistic from W-test Mann-Whitney-Wilcoxon	114	75,5	131,5
p-value	0,9669	0,1299	0,4424

On the other hand, no significant difference is to be noted between the use of strata according to the vertical plane of the forest in dry and wet season (p-value >0.05).

Variation in behaviour according to the type of individuals

The activity pattern of individuals was also assessed on an individual basis. The variables tested were the sex and age of the individuals. The categories compared are males and females of all ages. On the other hand, juveniles and adults are compared, all sexes combined.

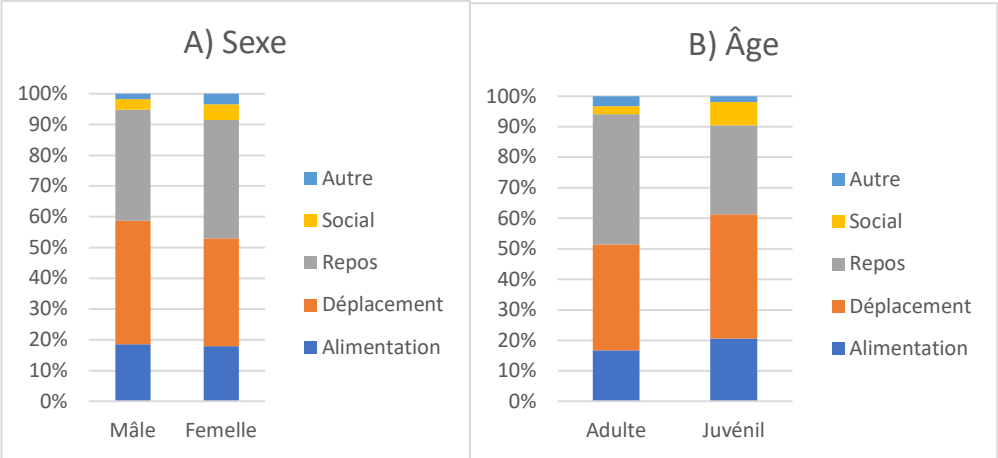

Figure n°8 : Percentage representation of the activity pattern according to sex (left - A) and according to age (right - B)

I) The percentage of time devoted to each activity are compared by gender and by age group. The results of the Chi-Square test carried out give a p-value=0.03392 for the gender comparison and a p-value=9.39e-11 for the age group comparison. Adults spend on average 42.7% of their time at rest compared to 34.3% for juveniles. On the other hand, social interactions for juveniles represent 9% of their activities compared to 2.5% for adults (Figure n°8).

II) The percentage of time devoted to each activity according to gender or age group is relatively homogeneous on average over a year. There is a significant difference only between adults and juveniles for rest and social interactions. Adults spend on average 42.7% of their time resting compared to 34.3% for juveniles (p-value = 0.008547 < 0.05 , W=170.5 ; Mann-Whitney-Wilcoxon test). Social interactions for juveniles represent 9% of their activities compared to 2.5% for adults (p-value = 3.971e-5, W=161; Mann-Whitney-Wilcoxon test) (Figure n°8).

Feeding behaviour

Simultaneously, dietary behaviour was studied for each period and the items consumed were identified where possible.

A total of 667 individual feeding events were counted with a total duration of 3919 minutes or 65 hours and 19 minutes.

For the dry season, 39.1% of the events corresponded to the consumption of fruit, which represents 49.7% of the time individuals eat. 51.1% of the events reflected the consumption of leaves, which corresponds to 45% of the time they spend eating. Finally, 9.8% of events reflect the consumption of other types of food, which accounts for 5.3% of the time for this activity.

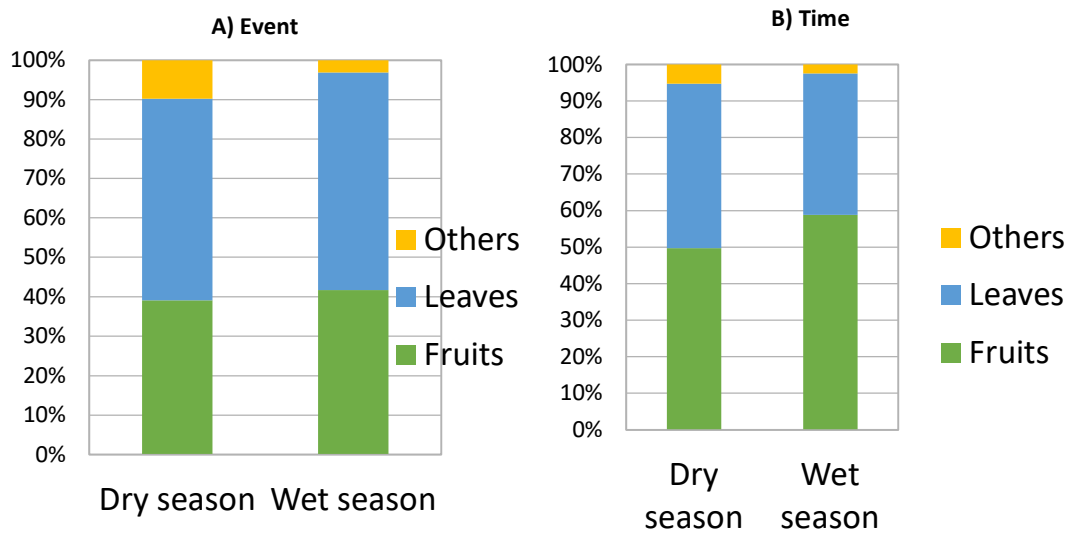

Figure 9: A) Percentage representation of the number of events (left - A) and time spent (right - B) on food consumption according to the season.

For the wet season 41.7% of the events include the consumption of fruit but this includes 58.8% of the time individuals eat, 55.1% of the events correspond to the consumption of leaves but only 38.7% of the

time they spend eating and 3.1% of the events constitute the consumption of other types of food for 2.5% of the time spent on this activity (Figure No. 9).

I) The statistical analysis shows a significant difference between the consumption of fruits, leaves or other foods between the dry and wet season, with a p-value=0.002008 for consumption according to the number of events and with a p-value=3.65e-10 for consumption according to time.

II) Statistical analysis shows no significant difference in fruit, leaf or other consumption between the dry and wet seasons, with a p-value always higher than 0.05 according to the Mann-Whitney-Wilcoxon test.

Family name	**Scientifique name**	**Nom commun**	**Dry season**	**Wet season**	
Achariaceae	*Mayna parviflora*			x	
Anacardiaceae	*Spondias mombin*	Mombin jaune	x	x	
Araceae	*Homalomena*	Philodendron	x		Leaf
Arecaceae	*Astrocaryum huicungo*	Huicungo	x		
	Attalea phalerata	Shapaja	x	x	
	Euterpe precatoria	Wasaï	x	x	
	Socratea exorrhiza	Cashapona		x	
Cecropiaceae	*Pourouma cecropiifolia*	Uvilla	x	x	
Cyclanthaceae	*Evodianthus funifer*		x	x	Leaf
Fabaceae	*Inga sp*	Inga		x	
Menispermaceae	*Anomospermum grandifolium*		x		
Moraceae	*Brosimum latescens*		x	x	
	Clarisia racemosa		x	x	
	Ficus americana		x		
	Ficus coerulescens		x		
	Pseudolmedia laevis		x	x	Leaf + Fruit
Myristicaceae	*Iryanthera juruensis*		x		
	Virola flexuosa		x		
Nyctaginaceae	*Neea sp.*		x		
Sapotaceae	*Pouteria sp*		x		
Sterculiaceae	*Theobroma sp*		x		
Violaceae	*Leonia crassa*		x	x	

Table n°6: Inventory of plant species consumed by stems according to season

During the study period (May 2018 - April 2019), 22 plant species were identified that the reintroduced spider monkeys consumed at least once the fruit or leaf. These species are divided into 14 families. This inventory includes only 2 species whose leaf consumption could be identified, for an Araceae and for a Cyclanthaceae, the consumption of the second item is very frequent in all seasons, these two species are epiphytes. Leaf consumption was also observed from a tree generally visited for these fruits: Pseudolmedia laevis, for the other species listed in Table 6 only the fruits were consumed. Nineteen species were identified during the dry season and 12 during the wet season, nine of which were consumed during both seasons.

DISCUSSION AND CONCLUSION

Activity pattern

I) According to the Chi-Square test results, there is a significant difference in the behaviour of the spider monkey between the dry and wet seasons.

II) According to the non-parametric test Mann-Whitney-Wilcoxon, therie is no significant difference between the dry and wet seasons.

According to Wallace (2005), *Ateles chamek* rest less and travel more in the dry season because of the lower availability of food resources and the fact that they are more dispersed over their territory in the dry season. For this study, despite a significant difference, the results obtained vary little between the two seasons. During the evaluation of this population, the social fission-fusion behaviour of the spider monkeys was observed multiple times. Indeed, when food resources are abundant, mainly during the wet season, the groups studied 1 and 2 (Table n°1) are mostly in fusion within a group of up to 13 individuals. On the other hand, when food resources become scarcer, rather in the dry season, the "fission" of the group is more frequent. For this period, group n°1 disperses and migrates to a destination in the reserve that we do not know, while group n°2 is confined to a small perimeter where resources are abundant even in the dry season. On some occasions, during the fissions, group n°1 could not be studied but these periods did not last more than 2 months and it was always possible at some point to study the individuals of this group for each of the 2-month study periods.

The results obtained on average for behaviour over a year are consistent with the data obtained for these same groups in the post-reintroduction period and for a group studied by Wallace in Bolivia (2001).

Use of the vertical strat

Spider monkeys are the primates of the new world that spend the most time in the upper part of the forest. When they share their habitat with other species occupying this upper strat, such as woolly monkeys (Lagothrix) or howler monkeys (Alouatta), it is the latter that migrate to the lower strata at the contact of the spider monkey (R. Mittermeier, 2013). As expected, 58.7% of the time spent in the canopy is therefore observed, followed by 30.1% spent in the overstory and 11.2% of the time in the understory.

A significant difference is observed between the two seasons for the occupation of the vertical strata, on the other hand a significant difference is observed with these same individuals in post-reintroduction. Indeed, the latter spent 40.4% of the time in the undersory against only 12.5% of the time in the emergent layer. This can be explained by the past history of these individuals, formerly pets in contact with humans and subsequently placed in a rehabilitation centre before being reintroduced. They were therefore accustomed to move on the ground surface and unfamiliar with the upper strata of the forest, and the presence of man was perceived positively by the animal and encouraged it to descend to the lower strata when these were assessed.

Behavioural variation by type of individuals

There is a significant difference in behaviour according to the age and sex of the individuals. It is the social and resting behaviour of juveniles that is particularly different from adults. This is can be explained by a strong social interaction between juveniles when playing instead of resting.

According to Mittermeier (2013), males have more social interactions than females because in the social structure of spider monkeys, males are philopatric whereas females disperse once they reach reproductive age towards another population. Thus, males have a high kinship and social interactions among themselves more frequently than females. This phenomenon has not been observed for this group as it is composed of only one adult male: Sambo (Table n°1). Still according to Mittermeier (2013), males move more than females, especially during the dry season when the availability of food resources is limited. This phenomenon could also not be observed because, as previously explained when the

groups are "fissioned", group n°1 including the adult male is no longer observed because it cannot be found. At this time the males travel in small groups and patrol around the territory to ensure the availability of resources for the females and to guarantee themselves exclusive access to the females. These data and behaviour could not be highlighted for this study.

Territory of the reintroduced group

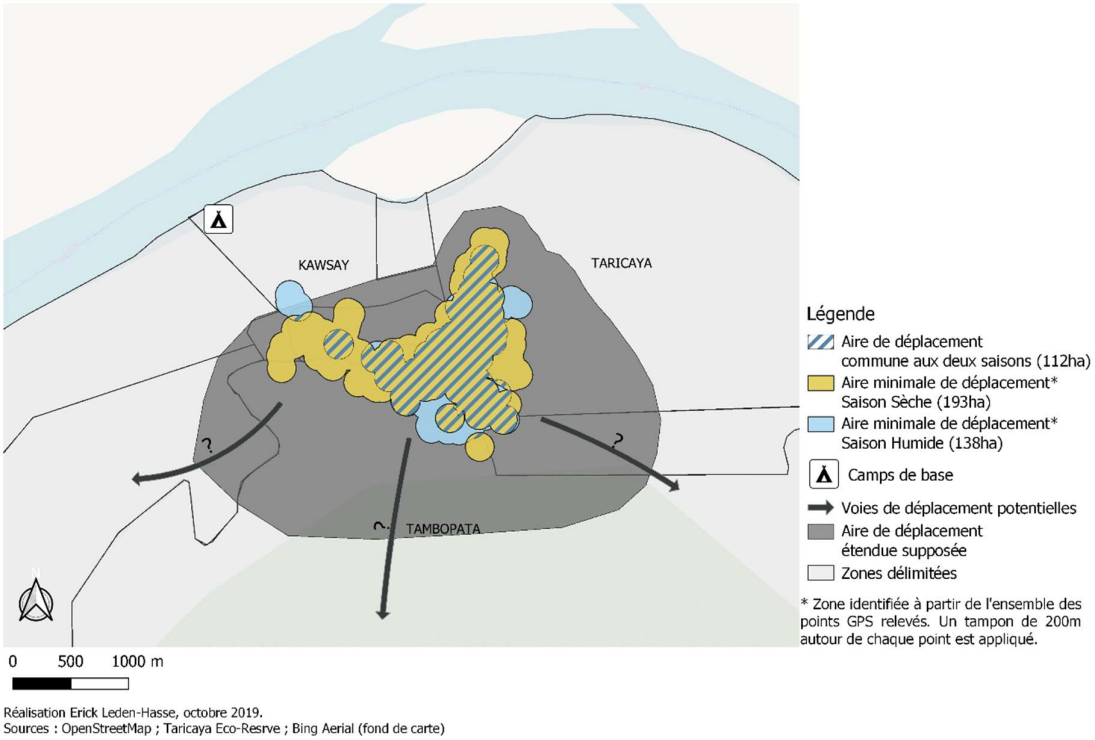

Figure No. 10: Distribution area of the reintroduced population between May 2018 and August 2019 for the two seasons

When monitoring the group of reintroduced individuals, a GPS point is recorded every 30 minutes in order to establish a map of the distribution air for this population. Data were collected between November 2018 and April 2019 for the wet season and between May 2018 and October 2018 and between May 2019 and August 2019 for the dry season. The additional four months in 2019 were added to this map in order to obtain a map that is as representative as possible of the distribution air for this group. According to Mittermeier (2013) the range of a spider monkey group is between 153 and 340 ha with an overlap of 10 to 25% between two groups. Firstly, it can be seen that the two areas in terms of season are broadly similar. During the dry season the area surveyed comprises 193 ha compared to 138 ha for the wet season. The fact that the area used by the primates is larger in the dry season can be explained by a larger amount of data. A wild group of spider monkey can comprise up to 50 individuals, so it is not surprising that the study group averaging 12 individuals has a measured range equivalent to the lower margin found in the literature. Moreover, this measured range corresponds well to the movement of group 2 whether the population is fissioning or merging in the last year, but when both groups are fissioning, group 1 explores and prospers in a larger area shown in dark grey in Figure 10. At various times while group 1 was under study, they were lost to the observer group as they moved outside the range shown on this map. But it seems clear that the survey area of group 1 is beyond 193 ha. It is difficult to estimate the true survey area during the fissions, this area must be close to the upper limits stated in the scientific literature (340 ha). Since this population studied does not have its territory overlapping that of other groups of individuals, these individuals are free to explore a large area.

Feeding behaviour

According to Campbell (2008), spider monkey are one of the most frugivorous primates of the new world. For this study, more leaf consumption events than fruit consumption events were reported for both seasons, but time spent consuming fruit is more important in both cases as well. Leaf consumption usually occurs as the group moves from one fruit tree to another or to a resting tree. Leaf consumption is generally a short event compared to fruit consumption that can last several tens of minutes and is a resource that guides the movements of the stems. Fruit trees are occasionally used as a resting tree once they finished eating the fruit concerned. This is particularly the case for trees belonging to the Moraceae family, which includes various species of ficus.

It should be noted that leaf consumption is very important for the species *Evodianthus funifer*, which accounts for more than half of the data obtained. They have only consume the leaf petiole of this epiphyte species, which is very abundant in their territory.

The consumption of other types of food includes seeds, flowers, and mainly palm bark, in particular, of the species belonging to the family Arecaceae: *Euterpe precatoria.* In addition, it includes the consumption of water retained in tree crevices and the consumption of mineral matter in what is known as "colpa" at ground level (see figure 11). This event has been observed twice during the dry season, when individuals ingest mineral elements present on the ground in an open area, probably in order to make up for a deficiency linked to a lower availability of resources during this season.

Figure No. 11: Picture of a "colpa" in the Tambopata National Reserve.

There is a greater percentage of time allocated to fruit consumption in the wet season than in the dry season with a significant difference [I) (p-value = 3.65e-10) II) (non significant : p-value > 0,05)].

Despite this, the data collected in the field come from a large number of reviewers, rarely experts, which creates a significant observer bias in the data. For the methodology of identification of food consumed, some data are missing in the wet season, especially in January and February 2019, this may explain the higher number of species identified for consumption in the dry season. In addition, about ten items could not be identified due to the lack of information available in the photos taken in the field.

Discussion of the reintroduction project

The objective of this reintroduction project is to obtain a metapopulation within the Tambopata National Reserve and that exchanges of individuals take place with the wild population present several tens of kilometres away within this same reserve. However, for the individuals previously captive and use to lived in the presence of humans, the latter could be healthy carriers of the human herpes virus, which can be fatal for the spider monkeys. A study is currently being conducted, in which the Kawsay Biological Station is participating, to determine whether reintroduced individuals and those born in the

wild carry the virus. It is obviously not desired to infect the wild population present in another part of the Tambopata National Reserve. To date, no reintroduced or wild-born individuals have shown symptoms related to this virus. Individuals in captivity at the Taricaya rehabilitation centre participating in this project were removed from the group or euthanized when these symptoms were detected in order not to contaminate the rest of the captive population.

General Conclusion

After 5 and 8 years following their reintroduction, the group of *Ateles chamek* now includes 7 individuals born in the wild. The study of their behaviour shows a representation of their activities and time spent in the different strata similar to wild populations. We distinguish with I) a Khi-Deux test a significant difference in their behaviour between the dry and wet season. These primates have a frugivorous-oriented diet and spend most of their time in the upper strata of the forest. They thus play a predominant role in seed dispersal and forest regeneration, and their long-term absence from this ecosystem has an impact on forest diversity.

The activity budget of juveniles differs from adults because of playing moments while adults are resting. There is a difference in behaviour between males and females, but the lack of monitoring of part of the group and the presence of only one adult male in the group does not make it possible to highlight behaviours specific to juveniles, such as a greater surface area covered by males and more social interactions between males.

The study of this reintroduced group of spider monkeys allows us to understand the use of their habitat and diet. This study highlights the use of the highest strata of the forest and their food preferences over the seasons. It is important to maintain a primary forest with high strata. Larger tree species such as shihuahuaco (*Dipteryx sp.*) and lupuna (*Ceiba pentandra*) are subject to illegal selective logging, more than 4,000 m3 of shihuahuaco were illegally harvested in Peru in 2018 . Their absence can affect the primates' habitat, and similarly these activities can affect the food supply of the forest (Moreno, 2018). Knowing the ecological characteristics of spider monkeys and the species they consume provides a better understanding of the functioning of tropical forest ecosystems, as they are considered to be dispersers of many key forest species. In the absence of spider monkeys, the composition of the Amazon rainforest and the interactions between species would not be the same and would probably lead to the extinction of several species. The shihuahuaco is used by different species of macaws (*Ara sp.*) and the ferocious harpy (*Harpia harpyja*) to locate their nests. Similarly, all tree species whose fruit consumption has actually been observed in macaws have key roles for other species in the forest ecosystem. The reintroduced monkeys thus contribute to the functionality of the forest as the only dispersers of large trees.

Figure n°12: On the left, a shihuahuaco over 50 meters high present in the Kawsay Biological Station © Erick Lenden-Hasse / Right, illegal cutting of shihuahuaco in Peru in 2018 ©Leslie Moreno

A long and medium-term study should be maintained to measure the influence of reintroduced monkeys in the forest, particularly on the effectiveness of their role as dispersers and their impact on the natural regeneration of the forest. It is necessary to know the ecological requirements of the species in order to plan conservation activities. Management measures for the protection of the species are necessary to ensure long-term protection, such as physical protection of the area.

Plans to reintroduce new groups of females and juveniles are planned for the coming years in order to increase the size and genetic diversity of the existing population. Furthermore, in order to allow the functioning of the groups in metapopulation, the reintroduction of new groups comprising at least one male at the periphery of the study group's habitat must be planned. The females migrate between populations once they reach sexual maturity, ensuring the exchange of individuals within a metapopulation.

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ANNEXE

Date: 21/03/2019				Evaluateur: Erick		Catégorie: AM		Climat: cloudy	
Hour	Activity					Strat			Observations
	Feeding	Travelling	Resting	Social	Other	Under story	Canopy	Emergent	
9:00		X					X		
9:05		X						X	
9:10			X					X	
9:15			X					X	
9:20				X			X		Interaction with JM
9:25					X		X		Vocalise in presence of bird of prey

Annexe n°1: Example of a behaviour and occupation strat evaluation sheet by scan sampling

Date: 21/03/2019		Evaluateur: Erick		Catégorie: AM	Climat: cloudy
Start	End	Aliment type	Aliment Support	Strat	Observations
09:27	09:42	Fruit	Vine	Canopy	Yellow fruit with several large berries, F1 code photo 130-000572
09:56	10:32	Fruit	Tree	Understory	Shapaja – *Attalea phalerata*
10:35	10:52	Leaf	Epiphyte	Canopy	Consumes the petiole only – *Evodianthus funifer*
10:56	10:58	Leaf	Tree	Emergent	

Annexe n°2: Example of an evaluation sheet for eating behaviour by Ad libitum