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Development of a Wild Infant Woolly Monkey

Social interactions, time allocation and behavior of a wild *Lagothrix lagotricha poeppigii* infant and her mother

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ABSTRACT

The lowland woolly monkey (*Lagothrix lagotricha poeppigii*), like all species of woolly monkey, is extremely threatened due to anthropologic activities such as deforestation, petroleum drilling and commercial hunting across their habitat. Due to their low reproductive rate and low reproductive success in captivity, the captive population is decreasing every year as habitat loss increases. In late February of 2017 an infant female was born on the island of Sumak Allpa, a monkey rehabilitation organization and reserve in the western Ecuadorian Amazon. The woolly monkeys are completely independent on the reserve; and as such her birth marks the first time a wild infant has been born in a rehabilitation center. In a 21-day study the time allocation of both the mother and infant were evaluated, as well as their social interactions with the individuals from two troops on the island, specifically the dominant male. Over the past year the two troops, one adult with one male and one juvenile with two, have been overlapping, and in recent months have fluctuated between two troops and a single troop. The father of the infant is assumed to be a sub-adult male as copulation has only been observed with him and adult females. This study found that at the age of two to three months the infant was eating solid food, continued to nurse, moved independent of the mother and used her prehensile tail regularly. The infant allocated the most time to resting and locomoting, and the mother to resting, moving and eating. The dominant male showed attraction to the infant and the mother, and appeared to have accepted the infant although he is likely not the father. This indicates that rehabilitation centers in wild environments may be an effective mode of repopulation and conservation for *Lagothrix*.
Key words: Woolly monkey (*Lagothrix lagotricha poeppigii*), infant development, time budgets, primate conservation

RESUMEN

Los chorongos (*Lagothrix lagotricha poeppigii*), como todas las especies de *Lagothrix*, están extremadamente amenazados debido a actividades antropológicas como la deforestación, el desarrollo de petróleo y la caza comercial en su hábitat nativo. Debido a su tasa reproductiva baja y éxito bajo de reproducción en cautiverio, la población cautiva está disminuyendo cada año mientras la pérdida de hábitat está aumentando. Al final de febrero de 2017 una hembra infantil nació en la isla de Sumak Allpa, una organización y reserva para la rehabilitación de los monos en el Amazonía occidental ecuatoriano. Los chorongos son completamente independientes en la reserva; y por eso su nacimiento marca la primera vez que una cría salvaje ha nacido en un centro de rehabilitación. En un estudio de 21 días se evaluó la asignación de tiempo de la madre y la cría, y sus interacciones sociales con los individuos de dos tropas de la isla también, específicamente el macho dominante. Durante el año pasado, las dos tropas, una con un macho adulto y otra con dos machos jóvenes, se han unido, y en los últimos meses han fluctuado entre dos tropas y una sola tropa. Se supone que el padre de la cría es el macho sub-adulto, porque la cópula sólo se ha observado con él y las hembras adultas. Este estudio encontró que a la edad de dos a tres meses el bebé estaba comiendo alimentos sólidos, seguía amamantando, se movía independientemente de la madre y usaba su cola prensil regularmente. El bebé usaba la mayoría de su tiempo para descansar y moverse, y la madre lo usaba para descansar, moverse y comer. El macho dominante mostraba atracción a la cría y la madre, y parecía haber aceptado a la cría aunque probablemente no es el padre. Esto indica que los centros de rehabilitación en ambientes silvestres pueden ser un modo eficaz de repoblación y conservación para *Lagothrix*.
ISP Topic Codes: 604, 609,622

INTRODUCTION

Ecuadorian Amazon

The Amazon biome is one of the most biodiverse areas on earth, with millions of species, many of which have not yet been discovered or described. It touches nine different countries, including Ecuador, Brazil, Peru, Bolivia, Columbia, Venezuela, Guyana, Suriname, and French Guiana. However, due to rapid development, exploitation, and deforestation, forest cover is rapidly disappearing, threatening the existence of many native species. More specifically, the western Amazon is especially rich in biodiversity, and Yasuní National Park is one of the major protected areas within this zone. Due to its large size, large vertebrate assemblage, likelihood of maintaining wet, rainforest conditions during climate change related drought, and IUCN level-II protection, Yasuní has a large potential to sustain biodiversity. However, Ecuador's second largest untapped oil reserves lie with the park in an area known as the "ITT" block (Bass et al., 2010). The decision to develop this land for drilling threatens the sustainability of this biodiversity, including the primates among the 13 threatened 15 near-threatened vertebrates that are native to the park (Bass et al., 2010). The woolly monkeys involved in this study likely originated from Yasuní or nearby Tiputini national park due to hunting activity which has increased in many areas due to petroleum development.

Lagothrix

Woolly monkeys are native to the Amazon rainforest and are found in Ecuador, Peru, Columbia, Venezuela and Brazil. There are two species of woolly monkey: *Lagothrix lagotricha* and *L. flavicauda*. *Lagothrix lagotricha* has four subspecies: *L. l. cana, L. l. lagotricha, L.l. lugens,* and *L. l. poeppigii* which was observed in this study (Ange-Van Heugten, Timmer, Jansen, & Verstegen, 2008). *L. lagotricha* can be found in the eastern Andes in Columbia, the Rio Tapajos, the Mato Grosso in central Brazil, eastern Peru and Ecuador. *L. flavicauda* is primarily found in the eastern slope of Cordillera Central in northern Perú (Ange-Van Heugten et al., 2008). It has been argued that there are actually five separate species of woolly monkey, however, more recently molecular studies have supported the existence of only two species (Botero and Stevenson, 2014; Di Fiore A, Chaves PB, Cornejo FM, et al.,2015). This conflict in taxonomy has complicated the conservation status of the woolly monkey, and there is still not consensus in the literature.

Lagothrix lagotricha poeppigii, or the lowland woolly monkey, was the subspecies observed in this study. They are a subspecies of Woolly Monkey native to Ecuador, Brazil and Peru, found in tropical and subtropical terra firma and seasonally inundated primary forest between 200 and 1600 meters above sea level (Pablo R. Stevenson & Aldana, 2008).

Figure 1. Geographic distribution of *Lagothrix lagotricha poeppigii* (Stevenson et al., 2008).

Lagothrix are New World monkeys part of the family Atelidae, shared with howler monkeys (*Alouatta*), spider monkeys (*Ateles*) and muriquis (*Brachyteles*). There has been limited investigation on woolly monkeys, especially in comparison to other Atelidae species, but the number of studies are incresing. Serious study of wild *Lagothrix* began in the 1970s in Columbia, and continues in western and eastern Columbia, Brazil, and Ecuador (Yasuní National Park) especially with sub-species *L. lagothricha lugens, L. l. lagothricha, L. flavicauda* and *L. l.poeppigii* (Defler & Stevenson, 2014).

Woolly monkeys are one of the largest species of primates in South America, ranging from 5.5-10.8 kg in body mass and 508-686 mm in head to body length, with females typically being smaller than males (Ange-Van Heugten et al., 2008). They are covered with short, thick hair which ranges from black, dark grey to brown, and have a dark, naked face. Their bodies are muscular, and they have arms that are about the same length as their legs. Their prehensile tails are approximately as long or longer than their body length, with a pad near the end on the distal side to enhance grip. This strong tail is used as a fifth limb, and can support their entire body weight. *Lagothrix* typical live in large social groups with 20 to 40 individuals which include reproductive aged individuals of each sex, normally more females than males, and a dominant male (Di Fiore & Fleischer, 2005). Solitary males and male only groupings can occur, but this has not been observed with females (Di Fiore, 2002). Similarly, female dispersal has been observed between troops, but there is limited evidence of male dispersal (Di Fiore & Fleischer, 2005; Maldonado & Botero, 2009). Troops of 23-25 have been reported to have territories of 108-124 hectares, although larger territories have been recorded and territory tends to increase with increasing in troop size (Di Fiore, 2003).

Woolly monkeys are diurnal canopy dwellers, and feed primarily on fleshy fruit pulp, along with young leaves, and insects (Dew, 2005). Ripe fruit composes 60% to 83% of their diet, and insects 10% (Di Fiore & Rodman, 2001). When compared to other New World monkeys, *Lagothrix* are more active, spending between 60% to 70% of their time on subsistence activity or movement, and only 21% to 36% on rest (Di Fiore & Rodman, 2001). They are completely

arboreal, and travel exclusively by jumping or climbing between tree canopies. Unlike other New World monkey species, *Lagothrix* rarely drink from reservoirs, and instead obtain water from wet leaves or water filled tree caveties (Dew, 2005). In captivity females have been reported to have a mean life expectancy of 13 years (Barnes & Cronin, 2012).

Lagothrix also play important ecological roles in seed dispersal and germination (P R Stevenson, Castellanos, Pizarro, & Garavito, 2002; Yumoto, Kimura, & Nishimura, 1999). They eat the fruit of more than 200 species of plants, meaning they have the most diverse diet recorded of any ateline primate species (Di Fiore, 2004). They also consume fruits with large seeds that are rarely consumed by other animals, and may be key in these seeds' dispersal (P R Stevenson & Aldana, 2008). *Lagothrix* also frequently forage with squirrel monkeys and capuchins, and they are followed by peccaries, birds, and deer which are able to eat the fruits and leaves they leave behind (Ange-Van Heugten et al., 2008). Due to their size they have few predators, usually limited to large birds of prey such as eagles, large snakes like anacondas, and humans (Hector Vargas, personal communication).

Conservation

All *Lagothrix lagotricha* subspecies are threatened according to the World Conservation Union, and *L. flavicauda* and *L. lugens* are listed as critically endangered (The IUCN Red List of Threatened Species, 2016). This is despite the fact that these species live in protected areas, such as *L. l. poeppigii* in Yasuní National Park. However, these statuses have repeatedly changed between species and subspecies, and more research is needed in or to clearly define the threats to different *Lagothrix* populations across South America (Ange-Van Heugten et al., 2008).

The principle threats faced by woolly monkeys are anthropogenic. As roads and infrastructure development has increased, human populations and accessibility to markets and virgin forest have increased as well. This has caused increases in both subsistence and market hunting, which is amplified by the introduction of guns in place of traditional hunting methods. This increase in pressure is exacerbated by continued habitat loss due to agricultural and commercial activities on a local and industrial level, and has led to a more than 30% decrease in the woolly monkey population over the past 40 years (Stevenson et al., 2008). This follows a global trend as deforestation has been found to be the primary cause of species extinction (Pimm and Raven, 2000). In addition, habitat destruction and hunting can alter the natural behavior of existing populations, as well as create "byproducts", which are surviving young sold as pets (Papworth, Milner-Gulland, & Slocombe, 2013; Schoene & Brend, 2002). Furthermore, as *Lagorthix* are large and arboreal they have a lower tolerance for habitat destruction; roads easily fragment their habitat and restrict food sources and territory as they are unable to travel.

Reproduction and Offspring

In captivity is has been observed that mature females go into heat every three weeks with 3 to 4 days oestrus and seven months of pregnancy (Mack and Kafka, 1978). Interestingly, captive born females tend to reproduce sooner and faster at six years with a 25 month inter-birth interval, in comparison to wild born females who started at nine years with a 20 month inter-birth interval (Nishimura, 2003). Wild born females also experience lower reproductive success (Nishimura,

2003). In the wild, troops are generally composed of more females than males, and as *Lagothrix* are not monogamous females will mate with multiple males (Di Fiore & Fleischer, 2005). It has been found that males rarely are in close proximity to one another, and antagonistic and affiliative interactions are rare even in the context of mating (Di Fiore & Fleischer, 2005). Females have a similar relationship, described as "tolerant" by Fiore and Fleischer (2005), however they are more likely to show aggression towards copulating pairs. Instead, affiliation between the opposite sexes and younger to older males tends to be more common. Due to these behaviors, and findings that it is often the female who solicits the male before copulation, it is likely that female competition plays an important role in *Lagothrix* sexual selection (Di Fiore & Fleischer, 2005).

There is little information available on the behavior of wild *Lagrothix* infants and their parents, and few well documented cases of infant behavior in captivity. Infants are born weighting about 10% of maternal mass, and birth is generally in the presence of other individuals who may learn or assist during the process (Mack and Kafka, 1978). Hand rearing has had little success, and has been taken as a last resort for infants born in captivity after rejections by their mothers (Barnes & Cronin, 2012). During hand rearing, it was found that infants began to consume solids between 45 and 71 days old, and in captive populations mothers and infants have begun to wean between 18 and 24 months off of the mother's milk (Barnes & Cronin, 2012). However, there is no published data on weaning or nursing rates in wild populations. It has been reported from captive populations that mothers do not intentionally give their infants solid food, and instead infants often take food that falls or that their mother is eating. Although adult males handle and interact with infants, because females may mate with multiple males, it is likely that the males are unsure of parentage (Hector Vargas, personal communication). However, the dominant males will often still interact with offspring (Barnes, 2012).

Rehabilitation

Due to pressures like these, primate rehabilitation centers have been created to conserve populations of primates and ensure their survival in the wild. These facilities provide opportunities for education and research, as well as the reintroduction of individuals to repopulate their native habitats. However, less than half of the individuals in primate sanctuaries across the world are candidates for release (Trayford & Farmer, 2013). Successful reintroduction is dependent not only on safe habitat, but on the development of the skills and behaviors necessary for survival in the wild as well.

Furthermore, reproduction in captivity and/or confinement poses another significant barrier to conserving a viable population. Specifically, woolly monkeys are known to be hard to breed in captivity; they have high infant mortality rates and hand rearing is rarely successful, resulting in 0.65 births to every death in the captive population (Ange-Van Heugten et al., 2008; Barnes & Cronin, 2012). In captivity *Lagothrix* have also been reported to have a low intrinsic rate of natural increase, along with long time periods between offspring and a short reproductive period over their lifespan (Ange-Van Heugten et al., 2008; Mooney & Lee, 1999). For example, only 37.5% of captive females have been found to be reproductively active after two birth events (Nishimura, 2003). Other institutions such as zoos and sanctuaries have rarely been successful in replenishing their own populations, and many now choose to not take in more *Lagothrix* or to not

breed the individuals they already have (Ange-Van Heugten et al., 2008). Main causes of death in captivity include hyper tension related conditions, pregnancy complications, anaemia, congestive heart failure and symptoms similar to diabetes mellitus (Ange-Van Heugten et al., 2008; Heugten, Heugten, & Verstegen, 2010). Furthermore, about half of the individuals in captivity are sub species hybrids, which hinders their opportunity for release as well as the application of research from captive individuals to wild populations.

Sumak Allpa

Sumak Allpa is a non-profit primate rehabilitation center founded in 2006 by Hector Vargas in the Ecuadorian Amazon. The project is supported by the Internation Primate Protection League, and is centered around the protection of native primates from destructive anthropologic effects as well as the education of the global and local community on the importance of the protection of the rainforest and its flaura and fauna. All the primates on the island are rescued from the surrounding area due to animal-trafficking and other human impacts such as deforestation. As Vargas' project is known in the community, it is often notified if there is a pet or injured monkey in the area. The individual is then transferred to the island sanctuary which contains protected, primary forest, minimal human activity and few predators. After any necessary veterinary care, or rearing if the individual is an infant, they are freed on the island to live independently. Tours are also conducted on the island and function as a tool for education of the local and international community, but are conducted in small groups and infrequently so as not to habituate the monkeys to human presence.

The goal of this project is for sufficient offspring to be born to each species to allow for relocation into other protected areas in the Ecuadorian Amazon. Unlike many rehabilitation sanctuaries which claim to have goals of relocation that are never realized, Sumak Allpa will be carrying out one of the first primate reallocations in Ecuador in the winter of 2017 (Trayford & Farmer, 2013). Furthermore, as the monkeys live independently, they can develop the natural behaviors and skills they would need for reintroduction. Studies of their time allocation and social interactions are conducted regularly to assess their preparation for release. Past research conducted by students on the woolly monkeys and squirrel monkeys on the island indicate that they are both physically and mentally healthy on the island, possibly more so than individuals in the nearby Coca Zoo (Hallowell, 2015; Sanabria, 2014). The woolly monkeys on Sumak Allpa are currently on track to be translocated in approximately seven years once a third generation has begun on the island (Hector Vargas, personal communication). This may currently be the only woolly monkey translocation project in the world as no mention of woolly monkey reintroduction was made in a 2012 survey of primate sanctuaries, although they noted that there were likely twice as many sanctuaries than those that were surveyed (Trayford & Farmer, 2013). The outcomes of this future project are dependent on healthy offspring and reproduction, and if successful could have large implications for the future conservation of this species.

There are currently seven species of primates on the island, although it has the capacity to hold nine (Hector Vargas, personal communication). The current species include: Poeppig's Woolly Monkey (*Lagothrix lagotricha poeppigii,*), pygmy marmoset (*Cebuella pygmaea*), dusky titi monkey (*Callicebus moloch*), golden-mantled tamarin (*Saguinus tripartitus*), black-mantled tamarin (*Saguinus nigricollis*), white-headed capuchin (*Cebus capucinus*) and common squirrel

monkey (*Saimiri sciureus*). These species are some of the most threatened due to deforestation and illegal trafficking (Hector Vargas, personal communication). The presence of other primate species enhances the habitat for *Lagothrix* as they natural live sympatricilly with these species and will forage with some naturally in the wild, such as squirrel monkeys and capuchins (Ange-Van Heugten et al., 2008).

There are two troops of Poeppig's Woolly Monkey (*Lagothrix lagotricha poeppigii*,) on the island, one juvenile and one adult, consisting of 12 individuals in total (Hector Vargas, personal communication). Their behavior, diet, interactions and movement have been studied and recorded regularly to evaluate their preparation for release (Leichter, 2012). The individuals arrived to the center between 2006 and 2012, were released on the island and formed troops. As they were not formed based on kinship ties and natural movements, they can be considered artificially constructed troops. The individuals in the juvenile troop, two females and two males, arrived to the island in 2012. Before their introduction to the island they were kept in captivity, and once on the island were provided in season fruit but Sumak Allpa employees. They became independent as of 2013, and over the past year have begun to assimilate and interact with the adult troop more frequently. There is now an adult female that stays with the juvenile troop, and over the past four months the two troops have been combined. Multiple copulations were observed in late 2016 between the sub-adult male (one of the juvenile males) and adult female. No copulation events were observed with the adult male. Most notably, as of late February 2017, likely between the 24th and 26th, a female infant was born into the population to one of the adult females in the adult troop. During the duration of the study she was between two and three months old. Because of past copulation observations, it is assumed that the sub-adult male is the father of the infant. This birth gives one of the first opportunities to observe woolly monkey infant time allocation, behavior and social interaction in a wild and accessible environment. This information could be used to facilitate repopulation projects in the future, as well as support the viability of captive populations with more structure around the needs and natural behaviors of mothers and infants.
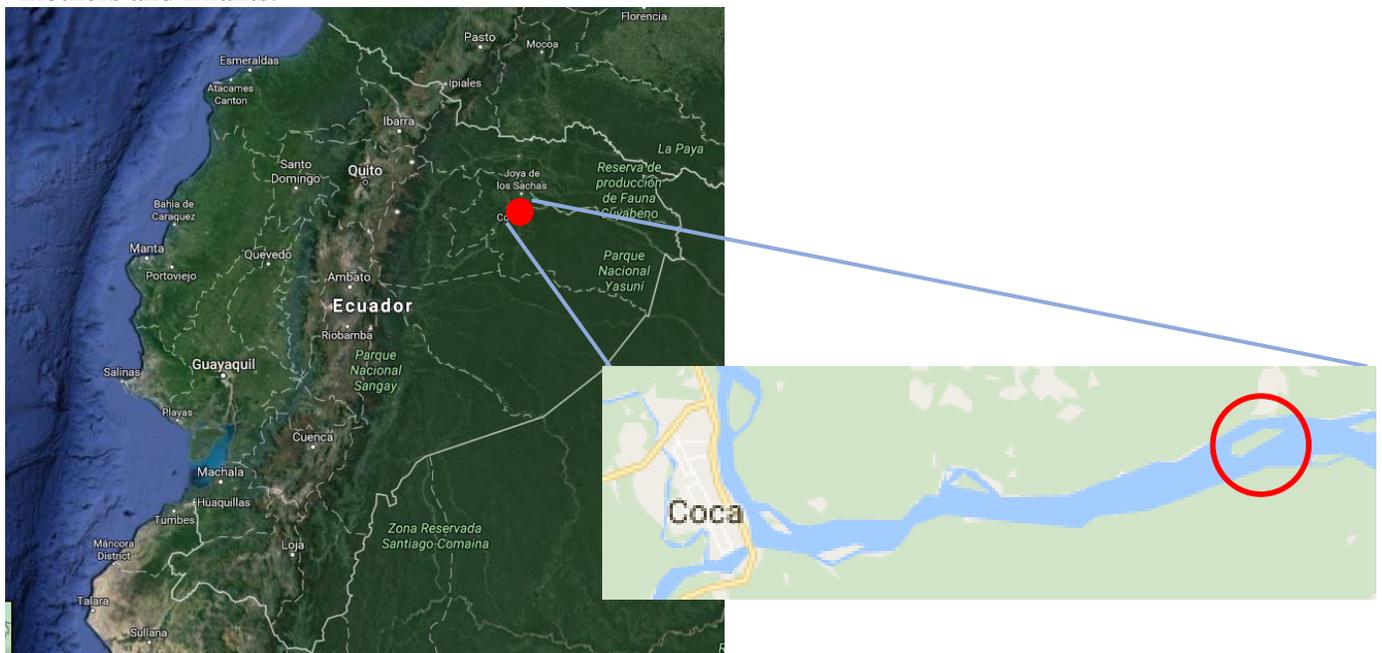

Figure 2. Sumak Allpa, Ecuador with a red dot and circle indicating its location.

METHODS

Study Site:

This study was conducted on Sumak Allpa Island, which is situated 30 km to the east of Coca, Puerto Francisco de Orellana, in the Napo river within the Orellana province of the Ecuadorian Amazon (0°26'22" S 76°49'02" W). The areas climate is characterized by warm temperatures averaging between 24°C to 27°C, annual rainfall is high at 3,200 mm, and humidity is high as well with an average of 80 to 94% which results in a mild dry season (Bass et al., 2010). The island is made up of 113.5 hectares, with approximately 3 kilometers of length and 860 meters of width. It is composed of varzea forest with various levels of flooding; some areas are regularly flooded while others are not. The forest is 70% primary and 30% secondary, and a small portion of the island has been developed for 4 cabins and a small dock. There are seven maintained trails for research and tourism, and the rest of the island is permitted to grow freely.

Figure 3. Google Maps image of Sumak Allpa with trails (Gallegos, 2016).

Data Collection:

Data collection was conducted during the rainy season in 2017 from April 17th to May 8th with 20 days of observation due to rain and flooding conditions. There were two observation periods per day, between 7:00-11:00 and 15:00-18:00. Generally, woolly monkeys are most active between 5:30-10:00 and 15:00-18:00 in order to avoid the heat of midday; therefore, the hours of observation were conducted during the periods of highest activity with an hour of observation of the resting period (10:00-11:00) (Hector Vargas, personal communication). At the beginning and end of each observation period GPS points were be taken to record the movement of the mother and infant. Troop composition was also recorded during each session as the juvenile and adult

troops fluctuate between separation and union. A total of 34 periods of observation were conducted during the study, with a total of 33 hours and 8 minutes of direct observation of the mother and infant. The troop took between 10 minutes and 2 hours and 45 minutes to locate, and was located during each other these periods.

To locate the mother and infant at the beginning of observation periods, their last known location was first visited. They were then located with the use of visual and audio cues, such as the rustling of branches, woolly monkey calls and knowledge of their general movement patterns on the island. During the first 4 days of observation, Hector Vargas the residential owner and Julian Malaver the residential park guard, assisted in locating the troop. Habituation protocol was also used in order to establish contact with the troop and habituate them to the constant presence of an observer (Setchell & Curtis, 2011). A shortened version of their social call "eo-eooooo" was made at the beginning of each observation period to establish that the observer was an unthreatening presence. If the troop felt threated they may have change their behavior or moved, skewing the behavioral data.

Behavior

Focal observation was utilized with both the infant and the mother during each observation period; whenever either the mother or infant switched behaviors the time was recorded (Setchell & Curtis, 2011). The length of the direct focal observation period was dependent on the time the individuals were located, and observation was then carried out until the end of the observation period. It was possible to use focal observation for both individuals with a single observer as the two were never more than 5 meters apart. Due to their arboreal lifestyle visual observation of the individuals was routinely lost, in which case observation would continue if enough information was available (ex: falling fruit when eating, or branch movement when moving between trees), or would be noted as not visible and that time would be removed from the data of the observation period (Setchell & Curtis, 2011).

Sampling was not taken during heavy rain as woolly monkeys generally stop activity, likely due to visual and olfactory impairment. However sampling continued during light rain as they generally continue with typical activity during this time (Di Fiore & Rodman, 2001).

Infant

Measurements of the infant's behavior were recorded following the methods of (Rotundo, Fernandez-Duque, & Dixson, 2005), in which the location of the infant is noted: dorsal, ventral or ventrolateral, activity: feeding, locomoting and resting, and proximity to nearest group members. All occurrences of infant transfers from one individual to another, excursions in which the infant moves away and returns to parent, nursing, eating and play were also recorded. Plants which the infant ate were identified down to family or species level with the help of Vargas and Malaver.

Mother

Measurements of the mother's behavior were categorized following the methodology of (Di Fiore & Rodman, 2001). The mother's activity was categorized by five mutually exclusive behaviors: eat, forage, travel, socialize and rest (Table 1). Any social behaviors such as grooming, aggression, or time spent in proximity to other individuals (<2 meters) as well as their sex-age class, were also recorded (Di Fiore & Fleischer, 2005).

Behavior	Definition
Eat	To handle, process, or consume either plant food items or animal prey.
Forage	To search for animal prey while stationary or moving, to actively manipulate a substrate in search of prey (e.g., unrolling leaves, breaking apart branches, inspecting vine tangles) or to actively attempt to procure prey items from the substrate.
Travel	To change positions, either within or between tree crowns, exclusive of that movement taking place incidentally while searching a substrate.
Socialize	To be engaged in any behavior such as grooming or mating that involved one or more other individuals, usually in close proximity. To perform any of a variety of infrequent, self-directed behaviors (e.g., defecation and urination, self-grooming, solo play, scent marking, and inspection of scent marks) or to watch or display at the observer.
Rest	To be inactive in either a sitting, lying, or standing posture. Included in this category is time spent scanning the environment (e.g., vigilance) that was not obviously associated with foraging behavior

Table 1. Definitions of behaviors used for time allocation of mother ((Di Fiore & Rodman, 2001).

Data Analysis

Time allocation was calculated by taking the total time spent on each behavior and dividing it by the total direct observation time. Infant positioning on mother was calculated by dividing the amount of time spent at each position divided by total time spent on the mother. Frequency of social events for the mother, and feeding, excursions and social events for the infant were recorded every time they occurred, and were then calculated by dividing the number of observation periods they occurred by the total number of observation periods.

Maps of observed territory were generated using google earth and GPS points collected while following the adult troop. However, based off observations made by residents of Sumak Allpa and time spent unable to locate the troop, it was also necessary to create a map of the estimated territories. These were generated based off sightings by Vargas and Malaver. Trail intersections were used as landmarks to estimate the boundaries.

RESULTS

Time Allocation of Mother

Analysis of the mother's behavior showed that the largest time allocation was resting (33.3%), followed by traveling (26.7%), eating (25.3%), foraging (10.0%) and socializing (4.8%).
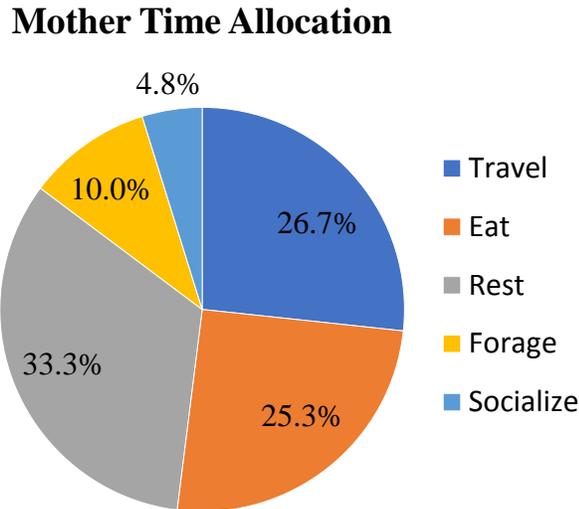
Mother Time Allocation

Figure 4. Mother time allocation.

Forage and Eat
The mother ate from a variety of fruit, leaf, flower and animal sources. Sufficient data was not taken to analyze the composition of her diet.

Rest
Rest usually consisted of one of two activities, active rest where the mother was alert and watching either the surrounding area or the infant, or inactive rest where she was sleeping while laying or sitting.

Socializing
Another individual was with 5 meters of the mother 19% of the time. During this time, adult females were present 65% of the time, and the adult male 40% of the time. The juveniles were never observed within 5 meters of the mother. Most instances of proximity to another individual were not initiated by the mother. One display of aggression was seen from the adult male to the mother and infant where physical contact was made. Both individuals stayed within the troop after the display, and no signs of aggression were seen over the next few observation periods.

Traveling
When traveling, the mother was frequently at the front of the troop while the adult male was at the back. Several occurrences of an adult female following closely behind the mother (< 2 meters) was observed, however no physical contact was made. When another individual of the

troop moved to her tree or near her she often changed positions and distanced herself and the infant from the individual.

Time Allocation of Infant

Analysis of the infant's behavior showed that the largest time allocation was resting (57.6%), followed by locomoting (37.8%), feeding (3.1%), and socializing (1.6%).
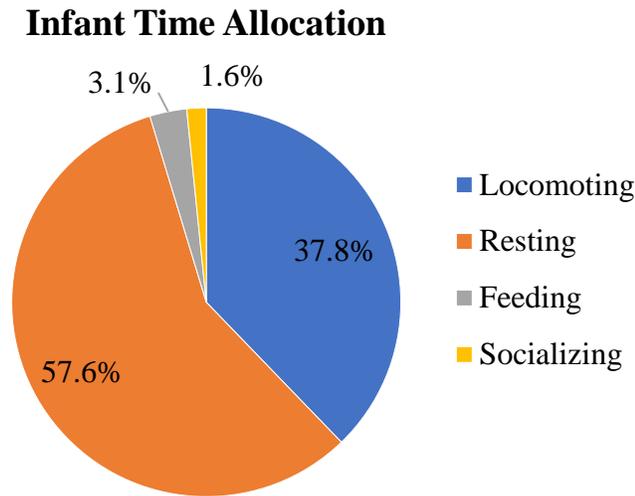
Infant Time Allocation

Figure 5. Infant woolly monkey time allocation.

Feeding

Feeding included both nursing and solid food consumption. Seventeen sessions of solid food consumption were observed during twelve observation periods, or in 35% of observation periods. Most consumption occurred while infant was position dorsally on the mother, while the remainder occurred while she climbing independently. Most food eaten was procured independently while the rest were taken directly from the mother. During one observed feeding session, the mother manipulated a branch towards the infant who then ate the fruit, without the mother feeding off the branch herself. All feeding events occurred while the mother was eating, foraging or resting. Fruit was eaten in 64% of eating sessions and leaves in 36%. The fruit sources comprised *Iriartea deltoidea, Inga sp., Artocarpus atilis, 2 Ficus sp.,* flower source *Philodendron sp.,* and leaves source Rubiaceae sp., *Ficus sp.,* and *Philodendron sp..* No consumption of animal prey was observed for the infant, although bark manipulation and observation of mother as she foraged and consumed animal prey was observed. Four episodes of nursing events were observed, each after the approach of the infant to the mother. Due to poor visibility, the duration and who initiated and terminated nursing were not observed.

Locomoting

Locmoting included any movement of the infant both on and off the mother. Movements on the mother included changing positions on the mother (ex: dorsal to ventral), manipulating leaves and branches while the mother was not moving, and the use of her tail on surrounding branches while the mother was not moving. The infant's movements off the mother included climbing both above and below the mother, following the mother as she foraged, hanging by her tail, and climbing next to the mother with one limb still in contact with her body. Excursions ranged approximately from 0 to 5 meters from the mother, including occasions where the mother moved to forage and distanced herself from the infant.

All locomoting activity was independent and utilized all limbs and tail with no assistance from the mother or any other individual. No independent tree crossing, from one to tree to another, was observed for the infant. Four occasions were observed in which the infant was climbing independently (>1 meter from mother) and made distressed vocalizations. During one of these occasions the mother returned to the infant and the infant climbed onto the mother.

Resting

Resting was observed exclusively while the infant was on the mother, the most majority of this time was spent in the dorsal position. However, during longer periods of rest (>15 minutes) ventral and ventrolateral were more common.

Socializing

Socializing events occurred when the infant interacted directly with an individual. Five social events were observed with members of the troop other than the mother, two with the adult male and three with adult females. During these events the infant either climbed on the individual, four times, or grabbed onto their arms, once. In three of the events the adult reached out first in a display of natal attraction. In one event with the adult male the infant left the mother and traveled approximately 5 meters to climb onto the male. In the remainder of the events the mother was <1 meter away from the infant. Two other instances of natal attraction occurred when an adult female visually inspected the infant from a close distance (<2 meters) but did not approach. No interactions were observed between the infant and any of the juveniles.

Interactions with the mother apart from feeding included observation of infant by mother and vice versa, the infant touching the mother's face, and the infant attempting to manipulate food or branches in mother's hands. Only auto-grooming was observed, no grooming was noted between infant and mother.

Play

Apart from the interactions during social events, four sessions of independent play were observed. Each consisted of the infant carrying and manipulating a stick, either on or off the mother.

Time on and off Mother

The infant spent 69.4% on and 30.6% off the mother, this includes both time resting, climbing and playing on the mother's body. During time spent on the mother the most common position was dorsal (69.4%), followed by ventral (22.8%) and ventrolateral (7.7%).

There appeared to be an increase in time spent off mother during the course of the study, however there was not sufficient data to support a significant relationship between infant age and excursion time.
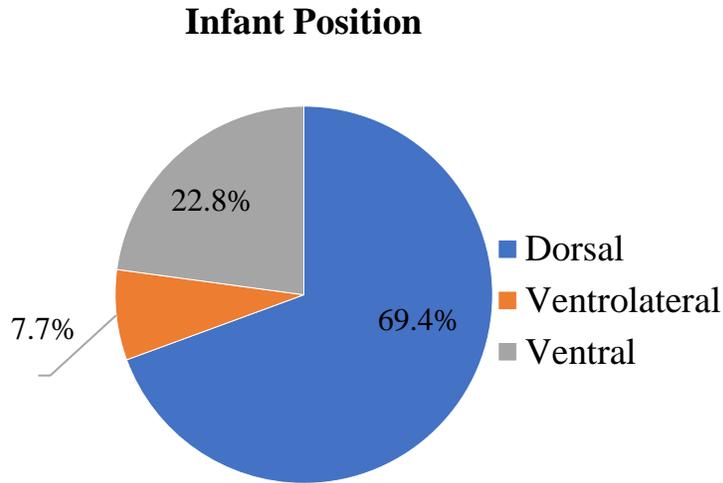
Infant Position

Figure 6. Infant position on mother

Troop Movement

The two troops were observed together during 18% of observation periods. No interaction between the juveniles and the mother or infant were observed. The juveniles tended to stay to the outskirts of the combined troop, however the females tended to be more integrated than the males, especially the sub-adult male who stayed distanced from the troop. When the juvenile troop was observed while in search of the adult troop it was composed of the four juveniles at the adult female.
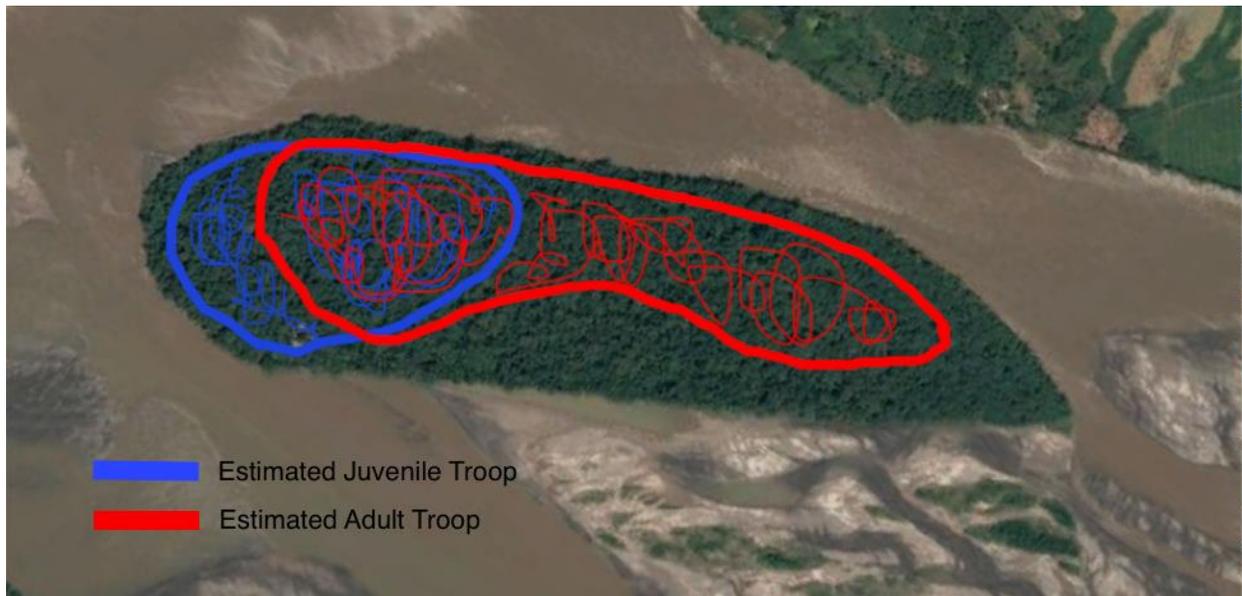
[A]
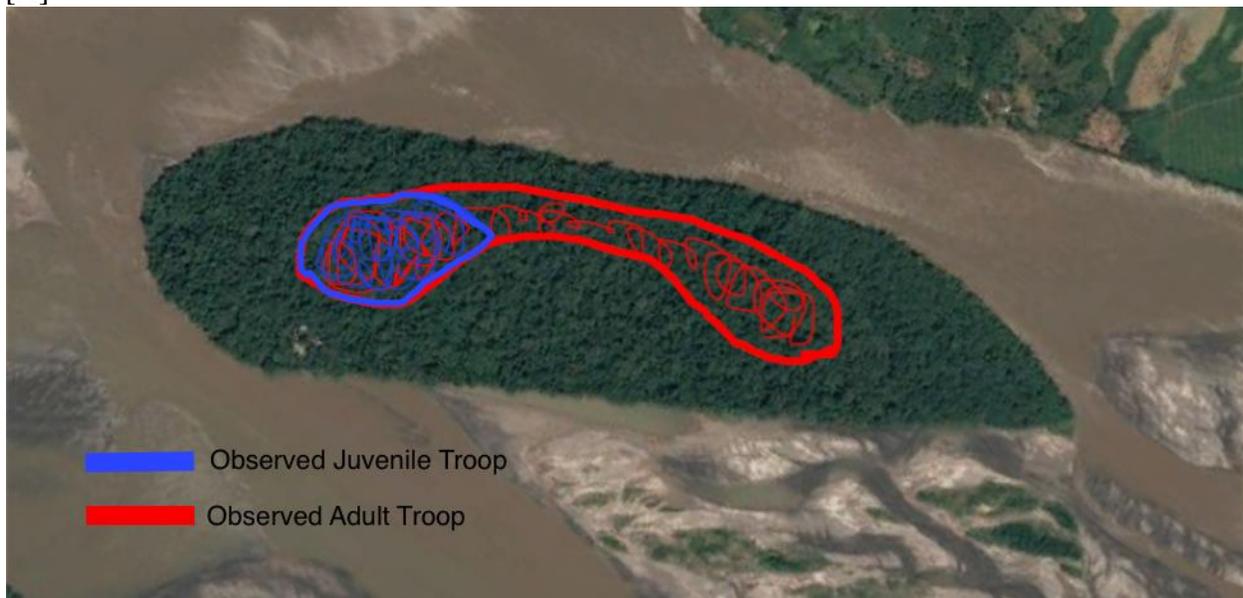
[B]

Figure 7. [A] Observed territories of adult and juvenile troops. Juvenile troop was only observed in shared territory as they were never followed exclusively. [B] Estimated territories of adult and juvenile troops based on observations by island residents and troops movement.

When the troops were separated two episodes of territory marking were observed. Both occurred in the shared territory when the troops were not together; one by the adult male, and the other by the sub-adult male.

DISCUSSION

Time Allocation of Mother

Analysis of the mother's behavior showed that the largest time allocation was resting (33.3%), followed by traveling (26.7%), eating (25.3%), foraging (10.0%) and socializing (4.8%). Few studies have been conducted comparing age and sex differences in time allocation patterns of *Lagothrix*, but significant differences between juveniles and adults, and females and males were found (Cartagena-Matos, Gasnier, Cravo-Mota, & Martins Bezerra, 2017; Shanee & Shanee, 2011). In the study conducted by Shanee and Shanee (2011) with a wild population of *L. flavicauda* it was found that females less time resting, especially those with infants, but more time eating and foraging as well. However, a direct comparison cannot be made with the mother on Sumak Allpa as *L. flavicauda* is a different species. The opposite trend was seen with semi-captive *L. l. cana,* females were found to spend more time resting and foraging than males (Matos et al., 2016). This is partially supported through the comparison of the mother's data in this study to the observations made by Di Fore and Rodman (2001) in Yasuní National Park with two troops of *L. l. poeppigii*, who showed less rest and more movement than the time allocation of the mother in this study (Fig. 8). It is possible that the extra energy needed to nurse and carry the infant has caused a greater time allocation to resting than the average population, and could be influenced by the confined nature of the island when compared to wild populations in Yasuní.

It is also possible that the higher rest time allocation is due to a higher foraging efficiency, allowing for more time to rest. P R Stevenson et al. (2002) indicated that woolly monkeys with dependent offspring (< 1 year) forage more efficiently on fruits than dominant males. This may be due to the male recognizing his offspring, and displays differential aggression to other individuals. However, as it is assumed that the adult male is not the father of the infant on Sumak Allpa, it is possible that fathering the infant is not necessary for the dominant male to show partiality.

It should also be taken into account that the hours 11:00 to 15:00 were not observed, and were assumed to be times of rest. Therefore the time allocation to rest is likely artificially low, for both infant and the mother.

Species	Class	Rest (%)	Foraging (%)	Travel (%)	Social interactions (%)	Other (%)	Reference
Lagothrix lagotricha poeppigii	Adult female with infant	33.3	35.3	26.7	4.8	_	This study
Lagothrix lagotricha poeppigii	Female infant	57.6	3.1	37.8	1.6	_	This study
L.l. poeppigii	_	23.2	36.2	34.5	4.7	0.7	Di Fiore and Rodman (2001)
L. flavicauda	Adult female with infant	18.3	35.5	29.7	0.7	15.7	Shanee and Shanee (2011)
L. l. lagothricha	_	41.9	26.6	31.9	_	_	Cant et al. (2001)
L. l. lagothricha	_	29.9	25.8	38.8	5.5	_	Defler (1995)
L. l. lugens	_	35	36	26	3	_	Stevenson (2006)
L. l. lugens	_	36	36	22.2	5.8	_	Stevenson et al. (1994)
L. l. cana	_	45	29	23	3	1	Matos et al., (2017)

Table 2. Time allocation in different species and subspecies of woolly monkeys *Lagothrix*

In Di Fiore and Fleischer's 2003 study of two troops of *L .l. poeppigii* it was found that woolly monkeys generally had another individual ≤ 5 meters from them 48% of the time. However, females with dependent offspring had non-juvenile neighbors 33% of the time, but that rose to 83.7% of the time if juveniles are included (Di Fiore, 2003). In comparison, the mother in this study only had

another individual ≤ 5 meter from her 19% of the time. This lower rate of proximity and association may be influenced by the juveniles separation in a different troop. Even when the troops were together no interaction was observed between the juveniles and the mother. This may change in the future if the two troops become more integrated.

Of the individuals who spend time in proximity of the mother, 65% were adult females and 40% adult male. As there was only 1 adult male and 5 other adult females on the island, the male was 3.3 times more likely to spend time close to the mother than an adult female. This is supported by previous studies which show that neighbor dyads are more likely to be of the opposite sex than of the same sex (Di Fiore & Fleischer, 2005). As female-female dyads are less common, the episodes of adult females trailing the mother are notable. It is possible that the adult female was experiencing natal attraction and wanted to interact with or observe infant care, especially as these adults had not had to the opportunity to be exposed to infants in the past.

The mother also tended to lead the troop during movements to different areas of the island. This may indicate that the infant elevated her status of dominance, however as it was not possible to tell the adult females apart the female hierarchy could not be examined. In contrast, the male was most frequently at the rear of the group, and was generally the most visible member of the group as he often sat on open, visible branches.

Time Allocation of Infant

As no previous studies of infant time allocation were found, the infant time allocation cannot be compared to existing data. Resting (57.6%) and locomoting (37.6%) were the two principle activities. Generally, whenever the mother was moving the baby was forced to rest while on the mother's body, and it appeared that the infant often began to move whenever the mother stopped, both for short or long periods of time. The infant was generally resting when the mother rested for longer periods (>15 minutes), but on one occasion the infant continued to climb independently while the mother appeared to be sleeping.

Figure 8. The infant resting on her mother on Sumak Allpa.

As the infant was eating solid foods and still nursing at two to three months, it appears that her eating development is paralleling both hand reared and captivity raised infants (Barnes & Cronin, 2012). She has begun to forage for her own fruit and leaves, but continues to share larger fruits such as *A. altilis* with her mother. The infant was already having vocalizing exchanges upon the beginning of the study, earlier than some hand-reared individuals which did not engage in vocal exchanges until 110 days old (Barnes & Cronin, 2012).

The infant stayed within an approximately 5 meter radius of the mother during this study, and did not ride on the body of another moving individual. The mother did not appear to monitor the infant's movement most of the time, and would often start to move before the infant had a chance to completely climb onto her. While the infant would periodically return to the mother, if the mother was foraging or eating she would generally spend most of her time moving if the mother stayed in the same tree. During one occasion the infant climbed independently for 54 minutes without returning to the mother.

The socializing aspect of the infant's behavior and the adult and sub-adult male were of especial importance during this study (the juvenile male is not discussed here as he is less developed and more juvenile than adult). As these are artificially composed troops they lack the familial lines that would normally be present in a troop. In a wild troop, the females may disperse before reproduction, and the males would become sexually active in their natal groups (P R Stevenson et al., 2002). According to kin selection theory, in a male-philopatric species such as *Lagothrix* males may associate preferentially with one another (Vigilant et al., 2001; Di Fiore and Fleischer, 2005). This would lead to more cooperation between males than between females in a troop, and less conflict among the males in competitive inter-group encounters such as reproductive opportunities. Following this theory, more aggression between the females on Sumak Allpa may not be expected, however it may influence the behavior of the males. As the adult and sub-adult male are not closely related, they may display more aggression than typically seen in males in the same troop. Furthermore, as they still occupy separate territories and troops, more aggression would be expected as adult males that have been observed attempting to enter new troops have been expelled by the resident troop's males (Di Fiore & Fleischer, 2005). No aggression was observed between the two males, but there was little integration which is expected as adult males do not normally interact frequently.

No interaction was observed between the sub-adult male and the mother, and as he is assumed to be the father this may indicate that male woolly monkeys are not able to recognize their offspring. However, it is also possible that the dominance of the adult male has kept the sub-adult male away from the female, especially as he is often in close proximity to the mother and infant.

Of the social contact made by the infant with other individuals, 40% were with the adult male and 65% adult females. The adult male showed no signs of aggression, and initiated physical contact with the female on most of the occasions. The infant climbed freely on the male, and on one occasion climbed approximately 5 meters away from the mother and climbed on the face of the adult male who engage in play with the infant with his arms. Because the infant is likely fathered by a male of a different troop, it is significant that the adult male has accepted the infant into the troop and treats her with affection as seen by fathers of infants (Barnes, 2012). This is promising for rehabilitation projects in the future as there is no guarantee that the dominant male in a troop will always have reproductive success.

Nine sessions of play were observed during the study, 4 independently and 5 with other adult individuals. The low levels of play observed may be in part due to the absence of juveniles integrated into the troop who would be more likely to be in close proximity to the mother as juveniles have been found to spend the most time engage in social activities, especially play (Di Fiore & Fleischer, 2005; Shanee & Shanee, 2011).

Troop Movement

The troops appeared to merge almost whenever the adult troop entered the shared territory, which was generally every few days. More vocalizations, both of aggression and socialization were generally heard while the two troops were together, however that may simply be due to the greater number of individuals in the area. Based on maps created by (Gallegos, 2016), it appears that there have been minimal changes to the troops' territories apart from a possible slight increase in the estimated adult territory. However, as the juvenile troop was not followed exclusively in this study it is possible that their territory has changed but was not observed.

As all observations were conducted by a single observer, bias on activity categorization was minimalized. However, due to the arboreal life style of *Lagothrix* the data may have been skewed towards more visible activities such as movement, or sedentary activities such as rest when the mother and infant could be observed without interruption.

CONCLUSIONS

This study documented the behaviors of the first female infant *Lagothrix lagotricha poeppigii* born in a wild rehabilitation center and her mother during the ages of two to three months. The data suggests that the infant is developing normally, and that the adult male has accepted the infant as part of the troop, despite its likely parentage by a male in a separate troop. As the two troops are spending more time together than in the past, it is likely that more births will occur in the near future (Gallegos, 2016). The successful birth and development of this infant indicates that rehabilitation centers in protected wild environments such as Sumak Allpa maybe the most effective mode of woolly monkey repopulation when compared to the high mortality rates in captivity.

The infant's progress and development should continue to be monitored, especially the behaviors and time line surrounding weaning and the beginning of the juvenile stage as this has not been observed in wild *Lagothrix*. The adult male and sub-adult male interactions should also continue to be monitored as they may determine infant success in the future.

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