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Use of Vertical Enclosure Space and Species-Typical Locomotion by a Rehabilitating Spider Monkey (Ateles fusciceps)

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Abstract

With wild spider monkey populations in decline, investigations contributing to captive welfare, and successful rehabilitation and reintroduction knowledge is increasingly pressing. Quantifying and analyzing the appropriateness of naturalistic enclosure designs to foster species-typical behaviors is an effective way to address both of these needs. This study investigates enclosure space use, vertical space preference, substrate use, positional/postural modes, and interactions with human caregivers of a wild-caught, pet-trade rehabilitant Columbian black spider monkey (*Ateles fusciceps rufiventris*, *N* = 1). Video data collected daily from August to October 2015 via focal animal sampling (from 08:00 to 10:00) at Alouatta Sanctuary, Panama provided samples for analysis. It was hypothesized that the subject would differentially utilize her enclosure's vertical space, substrates, positional/postural modes across substrate types, and vary her association with humans over time. Results indicated the subject's overall use of species-typical locomotive modes did not resemble that of wild populations, but did represent substrate-specific wild locomotive modes. Similarly, the subject's use of vertical space was significantly affected by the presence or absence of her human caregivers. This research highlights key points absent in existing literature: the need for enclosures constructed by materials resembling wild substrate-types, and the consideration of caregivers' influence when rehabilitating New World, arboreal primates.

Keywords: Ateles, rehabilitation, naturalistic enclosures, species-typical behavior

Use of Vertical Enclosure Space and Species-Typical Locomotion by a Rehabilitating Spider Monkey (*Ateles fusciceps)*

Compared to Old World monkeys and apes, sparse literature exists on New World primates, and spider monkeys (genus *Ateles*) are no exception to this general trend. The International Union for the Conservation of Nature (IUCN) Red List of Threatened Species (2015) classifies two *Ateles* species as critically endangered (*A. fusciceps, A. hybridus*), four as endangered (*A. belzebuth, A. chamek, A. geoffroyi, A. marginatus*), and one as vulnerable (*A. paniscus*). With wild populations in decline, research on *Ateles* is becoming increasingly difficult, accelerating the urgency of investigating best practices of spider monkey rehabilitation, reintroduction, and captive care. Major threats facing this genus include habitat fragmentation, logging, and subsistence hunting (Cowlishaw & Dunbar, 2000; Di Fiore, Link, & Campbell, 2011; Cormier & Urbani, 2008). Relatively no literature contributes knowledge on the needs of spider monkey enclosure design or captive husbandry standards, let alone studies of successful rehabilitation and reintroduction. Proper enclosure design is essential to fostering naturalistic environments in captivity and aiding in acquiring information of species-typical behavioral repertoires. Naturalistic habitats foster such behavior, enhance psychological wellbeing, ensure species-typical locomotion through adequate vertical and horizontal space, and enhance reproductive success (Beisner & Isbell, 2008; Bettinger, Wallis, & Carter, 1994; Coe & Maple, 1987; Davis, Schaffner, & Smith, 2005; Hebert & Bard, 2000; Jaman & Huffman, 2008; Jensvold, Sanz, Fouts, & Fouts, 2001; Maple & Finlay, 1986). Enclosures designed to foster naturalistic behavior are imperative to provide environments conducive to the maintenance of viable captive breeding populations and for possible reintroduction programs (Snowdon, 1991; McDaniel, Janzow, Porton, & Asa, 1993).

Literature Review

Natural History of *Ateles*

Spider monkeys (*Ateles spp.*) likely diverged from the *Brachyteles* genus, both evolving from *Lagothrix* in the South American lowland rainforests. Today, the genus, classified in the family Atelidae, is widely distributed across Central and South American tropical rainforests and is found the furthest North of any New World primate (Di Fiore et al., 2011). Spider monkeys are completely arboreal with adaptions specific to their semi-brachiating locomotion: a prehensile tail, absence of thumb, elongation of other digits, and elongated limbs relative to trunk size (Erickson, 1963). Spider monkeys are considered to have one of the largest relative biomasses of all New World primates, and because of this, they are at increased risk of subsistence hunting (Cowlishaw and Dunbar, 2000; Di Fiore et al., 2001). Spider monkeys, being 75 to 93% frugivorous, are important seed dispersers, and inhabit the high canopy to access such valuable fruits. To support such high-demand foraging in large, multi-male/multi-female social groups, spider monkeys have adapted daily fission-fusion dynamics. These groups are male philopatric, with females dispersing at maturity (between four and five years of age) (Di Fiore et al., 2001; Wolfheim, 1983; Kinzey, 1997). The home ranges of these groups has been reported to reach up to 250 hectares with 10 to15% overlap between neighboring groups; day ranges of males can be almost twice that of females (Symington, 1988).

Threatening Factors

Because of the need for large home ranges to obtain large amounts of fruit resources, the members of this genus are at risk of influence from logging, hunting, and collection for the pet trade (Di Fiore et al., 2001). Parts of primary forests in Central and South America are commonly cleared for urban expansions and use as agricultural fields. This systematic loss of habitat poses many challenges to primate populations. Notable decrease of primate population densities and 100% infant mortality were cited in *Hylobates lar* and *Presbytis melalaphos* of the Tekan Forest as a byproduct of logging and increased human presence (Cowlishaw & Dunbar, 2000; Grieser Johns & Grieser Johns, 1995). In spider monkey populations specifically, logging has been shown to have extremely negative effects. Rimbach et al. (2013) found spider monkeys to have comparatively higher outputs of glucocorticoids in areas of human impact, suggesting negative long-term impacts on population viability due to chronic stress. These results indicate humans not only impact a population's immediate survival but also long-term viability. Further, indirect long-term effects of logging have been shown to inhibit spider monkey population size through habitat fragmentation and loss of vital feeding tree species (Gutierrez-Granados & Dirzo, 2010). Within fragmented forests, spider monkeys readily adapt their social and ecological behaviors to cope with fragmentation and sustenance loss. Rimbach et al. (2014) explains these adaptions and their effects: as canopy connectivity declines, home range sizes must also decrease, which ultimately results in reduced available resources. This in turn decreases the adaptive fitness of species-typical fission-fusion social composition because fissioning parties are no longer able to venture away from one another to find the appropriate amount of resources. Combined, this equates to smaller, highly dense populations with significantly more aggression (over highly valued resources), increased folivory, and higher chronic stress levels, thus resulting in two-fold inhibitory effects of population size. Seemingly, short-lived human effects on spider monkey environments impact their socio-ecological behaviors for much longer than was previously assumed.

As these populations adapt to such environmental changes, they are forced to relocate to lower portions of the canopy in fragmented forests, making them visible to loggers and more susceptible to hunting. Primates who are considered to possess traits that are desirable to humans (e.g., quickness, intelligence) are often targeted and consumed by local and indigenous populations in hopes of acquiring the primates' anthropomorphic qualities. Meanwhile, species possessing undesirable traits (e.g., laziness, slowness) are not hunted for meat but may be collected and sold into the pet trade (e.g., howler monkeys; Di Fiore et al., 2001). With their arboreal speed, strong intellects, and large body masses, spider monkeys are ideal targets for subsistence hunters (Cowlishaw & Dunbar, 2000).

Studies have indicated primate populations, in general, can recover once relocated from anthropogenic areas to areas of less disturbed forests, but few primate species readily adapt to hunting pressures and maintain typical population numbers (Oates, 1996; Tutin & Fernandez, 1984). Specifically, spider monkey populations can continually recover in disturbed but regenerating forests if they are protected from hunting (Chapman, Chapman, & Glander, 1989).

Rescue, Rehabilitation, and Reintroduction

The anthropogenic effects that threaten spider monkey population viability and survival have led to the necessary rescue, rehabilitation, and reintroduction of individuals able to survive independently and supplement wild population sizes. If a rescued primate is to eventually be reintroduced into wild populations, it is imperative the individual(s) is/are successful in building the skillsets necessary for independent survival. In preparation to reintroduce rescued primates, Baker (2002) emphasizes the importance of using naturalistic enclosures situated in a wild setting to encourage animals to acquire the necessary wild skills for release. These naturalistic enclosures would closely simulate all aspects of the species' typical habitats. Unfortunately, no cited investigations contribute such knowledge to the rescue, rehabilitation, and successful release of *Ateles spp*. Therefore, the subsequent discussion will turn to the best practices for the naturalistic enclosure design of other species.

Naturalistic enclosures. Little consideration is made in rehabilitation/release publications regarding the design of enclosures that foster learning of species-typical behaviors.

Cheyne, Campbell, & Payne (2012) discuss the bare-minimum for constructing gibbon (*Hylobates* spp.) rehabilitation structures without mention of the features needed to foster species-typical locomotive styles (similar to that of spider monkeys). In the case of gibbons, the authors state that the construction of rehabilitation enclosures to foster naturalistic behaviors (e.g., brachiation) should be the primary goal of rehabilitation. However, beyond the mention of branching and swinging enrichment, little direction in designing appropriate enclosures is described (Baker, 2002; Cheyne et al., 2012). This exemplifies a challenge in rehabilitation to quantify the species-typical behavior necessary for independent survival and describe how these behaviors can be acquired through the specific construction of naturalistic enclosures. To enhance knowledge on the naturalistic enclosures necessary for primate rehabilitation, literature on captive enclosure designs can be consulted for supporting evidence in species' enclosure space use, preference, and designs for decreasing caregiver effects.

Naturalistic habitats in captivity have been shown to foster wild species-typical behavior, enhance psychological wellbeing, ensure adequate use of vertical and horizontal space, and enhance reproductive success (Ross et al., 2009; *Ateles fusciceps robustus,* McDonalds & Brickell, 2007; *Gorilla gorilla,* Coe & Maple, 1987; Maple & Finlay, 1986; *Pongo spp*., Hebert & Bard, 2000; *Papio cynocephalus anubis*, Else et al., 1986). While the mere presence or absence of species-typical behaviors is not the most appropriate measure, Maple and Perkins (1996) found captive rates of such behaviors most closely resemble wild rates in enclosures that represent the species' natural environment. Snowdon (1991) has identified three steps to achieve such successful naturalistic captive environments: (1) identify the natural environment, (2) select features that can be modeled in captivity with accuracy to true form, and (3) prove the outcome of the model through the increase of a species' normative behavior (Snowdon, 1991). These environments maintain species' motoric, social, and cognitive skills through the appropriate use of substrates and enrichment to develop normal locomotive modes. Successful captive environments for spider monkeys have also been suggested to positively impact the animals' levels of cortisol, where negative impacts lead to decreased wellbeing and reproductive probability (Davis, Schaffner, & Smith, 2005). When it is possible to reintroduce captive animals into wild populations, the enclosures and captive (or semi-captive) settings most resembling the natural environment will increase the likelihood that these individuals may acquire the skills necessary for survival (Baker, 2002; Beck et al., 2007). Attaining such skills necessary for independent survival is not possible if rehabilitating individuals learn to rely on their human caregivers.

Human caregiver contact. Continuing the discussion of rehabilitation success, many authors note the importance of reducing human contact as a rehabilitating individual approaches release (Beck et al., 2007; Campbell, Cheyne, & Rawson, 2015; Guy, Curnoe, & Banks, 2014). Mainly, this is a goal of rehabilitation to ensure the animal is able to survive in nature independent of human intervention (Beck et al., 2007). The most comprehensive sources for primate rehabilitation and release cite the ultimate absence of human support as a keystone for decisions regarding any individual's preparedness for reintroductions (Baker, 2002; Guy et al., 2014). Furthermore, the IUCN states a groups' suitability for release is partially dependent on their decreased contact with humans (Baker, 2002). However, it should be noted that a majority of the literature citing successful rehabilitation and introduction programs strictly relate to ape populations (chimpanzees, gorillas, orangutans, and gibbons); rescue and release program investigations of other taxa have yet to address the extent of human contact to near-release primate individuals. Even one of the most successful cases of wild repopulation does not account for contact with humans (*Leontopithecus rosalia*, Kierulff et al., 2012).

From the discussions of enclosure appropriateness and re-introduction survival it can be generalized that (1) enclosures at rehabilitation sites should foster the species-typical behaviors needed for survival post-release, (2) enclosures in captivity should foster similar rates of species-typical wild behaviors to increase psychological wellbeing and reproductive success, and (3) the degree of an individual's (or groups') readiness for release is partially dependent on minimal dependency and contact with humans. These generalizations assume the species-typical behavioral repertoire and rates of behavioral expression are known for a given species; of course, this is not always the case. For spider monkeys, much of the species-typical literature comments on the extremely advantageous adaptation to access resource on the terminal ends of branching in the upper most reaches of the canopy: semi-brachiation (Cant, Youlatos, & Rose, 2001; Di Fiore et al., 2001; Erickson, 1963; Rimbach et al., 2014; Youlatos, 2002).

Species-Typical Behavior

From the above sections, it is clear naturalistic enclosures are critical in establishing appropriate settings for rehabilitating and captive individuals. Often, to measure such enclosure appropriateness, authors compare observed species-typical behaviors and their rates of expressions with known wild rates (Coe & Maple, 1987; Davis, Schaffner, & Smith, 2005; Else et al., 1986; Hebert & Bard, 2000; Maple & Finlay, 1986; McDonalds & Brickell, 2007; Ross et al., 2009).

Rates of activity. In an investigation of enclosure space use by chimpanzees, Jensvold et al. (2001) found that the modes and manner of travel were indicators of species-typical behavior and therefore enclosure appropriateness. These chimpanzees were found to better match the locomotive modes and travel rates of wild chimpanzees after being moved from a small, indoor facility to the large, multi-variable, indoor/outdoor Chimpanzee and Human Communications Institute (CHCI). Similarly, Hebert and Bard (2000) found that appropriate enclosure design fostered orangutan species-typical behaviors, increasing active arboreal behavior when the enclosure floor was flooded. The results from Jaman and Huffman's (2008) study of captive Japanese macaques (*M. fuscata*) showed that enclosures designed to resemble natural environments (with vegetation versus without) directly correlated with increased activity budgets and contributed to an individuals' positive welfare. In research on captive rhesus macaques (*M. mulatta*), Beisner and Isbell (2008) found a positive correlation between natural enclosure ground substrates and more natural rates of both auto- and allo-grooming. It can be generalized that (1) activity rates resembling those of wild conspecifics increase captive primate welfare and wellbeing, and (2) captive groups displaying less active rates may have decreased welfare and wellbeing (Birke, 2002; Pruetz & McGrew, 2001; Yamanashi & Hayashi, 2011). Similarly, the rehabilitation and release literature also cites that it is necessary for rehabilitant individuals' activity rates to closely resemble or exceed that of their wild counterparts to ensure survival post-release (gibbons, Campbell et al., 2015; chimpanzees, Farmer & Jamart, 2002 in Baker, 2002; tamarins, Kierulff et al., 2012)

Spider monkey locomotion. To swiftly move through the upper canopy with a large body mass to access vital food resources (often at the flexible, terminal ends of branches) it is critical that spider monkey individuals employ species-typical semi-brachiation (Fleagle & Mittermeirer, 1980). Suspensory methods, such as adaptive tail-assisted semi-brachiation, aid navigation through the canopy, especially on the very thin ends of branches. By utilizing these adaptive suspensory methods, spider monkeys can successfully maneuver on thin supports, increasing their ability to access fruits (Grand, 1972 as cited in Kinzey, 1997).

Publications on spider monkey locomotive modes, rates, and postures are particularly helpful in establishing and identifying species-typical behavioral patterns. Youlatos (2002) investigated the differences between postural modes during feeding and locomotive modes during travel of *A. paniscus paniscus* in French Guiana. This investigation differentiated between *positional* (e.g., locomotive) quadrupedalism, bipedalism, clamber, climb, tail-arm brachiation, forelimb swing, other suspension, leaping and dropping, as well as *postural* (e.g., stationary) squatting, sitting, standing, bipedal standing, tail-only hang, tail-hind limb hang, tail-forearm hang, lie, and cling. The results of such comparisons showed that (1) suspensory modes were utilized most often in the main canopy, (2) clamber was more frequent on small supports, whereas tail-arm brachiation dominated on medium supports, (3) equal frequencies of clamber and tail-arm brachiation occurred during both travel and feeding behaviors, and (4) of observed feeding postures, squat was more frequent above a support, whereas the tail-only hang was more frequent below a support.

Investigating *A. belzebuth*, Cant, Youlatos, and Rose (2001) found significant differences between the size of the support and the locomotive modes utilized; dropping, leaping, and clamber occurred most often on weak supports of less than two centimeters, suspensory modes (primarily forelimb swing and brachiation) occurred most often on flexible supports between two and five centimeters, whereas bipedalism, quadrupedalism, and climbing (ascend/descend) occurred most often on stable supports from five to ten centimeters. These conclusions indicated a more intense use of the highest locations in the canopy, and of all observed locomotion, clambering, quadrupedalism, and suspensory modes were most common.

Youlatos (2008) compared studies of locomotive and feeding modes to derive the most frequent modes across *A. geoffroyi, A. paniscus,* and *A. belzebuth*. Based on the quantitative aspects, a relative generalization can be drawn: spider monkeys use extensive suspensory methods while locomoting, mainly tail-arm brachiation and forelimb swing. These results identify natural rates of vital species-typical locomotive and postural modes, providing a basis for indicating enclosure design effectiveness and enclosure space use in captivity.

Current Study

The purpose of this study is to provide insight into how a wild-caught, rehabilitating, female spider monkey (*A. fusciceps rufiventris*) uses her enclosure space. This investigation provides literature regarding the best practices for spider monkey enclosure designs to promote (1) an individual or groups' welfare and (2) appropriateness in acquiring vital species-typical locomotion for rehabilitation towards successful re-introduction. It is hypothesized that the subject (hereafter referred to as "Luna") will differentially utilize her enclosure's vertical space, substrates, positional/postural modes across substrate types, and vary her association with humans over time. To investigate this main claim, the following is hypothesized:

Hypothesis 1. Luna will spend unequal amounts of time on the ground and top of the enclosure, predicting Luna will spend the most amount of time in the elevated areas (Cant, Youlatos, & Rose, 2001; Di Fiore et al., 2001; Youlatos, 2002).

Hypothesis 2. When locomoting, Luna will use semi-brachiation and clamber more than any other mode (Youlatos, 2002, 2008; Grand, 1972, cited in Kinzey, 1997).

Hypothesis 3. Luna will move quadrupedally when on stable, relatively large and stable substrates (Youlatos, 2008).

Hypothesis 4. Luna will utilize suspensory modes most when on unstable substrates (Youlatos, 2008).

Hypothesis 5. Luna will utilize hanging suspensory modes (inclusive of tail-assisted hang) and resting modes (inclusive of sit, squat, and lie) most commonly when not in motion (Youlatos, 2002, 2008).

Hypothesis 6. To best resemble activity rates of wild populations, it is predicted that Luna's rates of activity/movement will increase over time (Bayne et al., 1992; Pruetz & McGrew, 2001; Yamanashi & Hayashi, 2011).

Hypothesis 7. Because of the rehabilitant methodology of the sanctuary where Luna resides (see Method), it is predicted she will differentially utilize her enclosure space with and without human presence, but a prediction of the direction of these differences cannot be made.

Hypothesis 8. As stated by many best practice guides for primate rehabilitation, it is critical that individuals have decreasing interactions with human caregivers (Beck et al., 2007; Campbell, Cheyne, & Rawson, 2015; Guy, Curnoe, & Banks, 2014); therefore, it is predicted Luna's associations and interactions with humans will decrease over time.

Comparisons of captive and wild *Ateles* populations are necessary for captive management decisions (McDaniel et al., 1993). The current study is ideal in that it incorporates captive management in a semi-wild setting. Luna's completely outdoor enclosure was built in the jungle on the Chiriquí Peninsula of Panama at Alouatta Sanctuary to best emulate a wild environment. The purpose of the sanctuary and this specific enclosure is to help Luna build her skillset toward release while remaining under the care and supervision of the sanctuary staff. This, therefore, posits a situation where the enclosure design and sanctuary husbandry policy can be investigated by measuring Luna's ability to reach typical benchmarks of release preparedness.

Method

Subject and Study Site

An adolescent, female Columbian black spider monkey (*A. fusciceps rufiventris*) was rescued in July 2015 with other individuals of differing species from a "pet collector" in Panamá City, Panamá. All individuals were confiscated by the Autoridad Nacional del Ambiente de Panamá (ANAM) and placed with Alouatta Sanctuary for rehabilitation and potential future release. Luna is the subject of the current study. She was estimated to be between the ages of one and two years (born in either 2013 or 2014) by her caretakers at the sanctuary. Because Luna was rescued from the pet trade, she was fully habituated to enclosures and human interaction at the start of the current study.

Sanctuary rehabilitation methodology. Alouatta Sanctuary management adopted a human contact-centered approach to neotropical primate rehabilitation, insisting human rehabilitators function both as behavioral enrichment and substitute conspecifics. Because Luna was singly-housed and the only spider monkey at the sanctuary, humans spent approximately two to three hours in her enclosure each morning as “social enrichment.” As a result, humans were Luna’s only source of social interaction, a significant consideration for an extremely social, large group living, primate species. No wild spider monkey populations inhabit the primary or secondary forests surrounding the rehabilitation site; therefore Luna could not partake in the sanctuary’s typical “bush outings” and soft release protocol as practiced with rehabilitating *Alouatta palliatta palliata* (for review see Schwartz, Hopkins, & Hopkins, 2016). However, there was potential for Luna to briefly interact with other monkeys through the caging of her enclosure; wild populations of *Cebus capuchin* and *Alouatta palliata palliata* frequently traveled through the rehabilitation site, but to our knowledge, Luna did not have physical interactions with any of these individuals. However, Luna did interact with rehabilitating and soft released individuals of these species; at least one soft released adult female *Cebus capuchin*, one soft released adult male *Alouatta palliata palliata* , and two rehabilitating juvenile female *Alouatta palliata palliata* occasionally interacted with Luna through the caging of her enclosure (typically in attempt to acquire food).

Materials and Procedure

This research utilized a house-shaped enclosure (base: 6.10m long, 6.10m wide, 12.20m high; triangular top: 6.10m long, 6.10m wide, 2.44m high; totaling 544.75 cubic meters) that was designed *ad libitum* with representative substrates simulating properties wild spider monkeys would encounter in nature (branches, rope, ground, and wire caging); special emphasis was placed on the incorporation of branches and ropes to encourage Luna's movement through her enclosure space. As spider monkeys are almost completely arboreal, branching and rope descriptively best represent natural canopy conditions. The enclosure design remained constant throughout the study with broken or damaged substrates being replaced and/or fixed as soon as they were rendered broken or damaged. Any substrate requiring replacement was replaced with material as close to the original as possible (e.g., the same species of tree, length/color of rope, etc.) and installed in the same place.

To control for natural variability, rain cover was equally distributed across the east apex and four identical feeding baskets were distributed evenly throughout the enclosure with any number of them randomly assigned for use each day. For this random assignment, the enclosure was divided into nine areas (see Appendix A). To control for Luna's personal food preferences, equal total amounts of food and equal amounts of each type of food were distributed among/between assigned feeding baskets. Food was also randomly scattered in multiple places throughout the enclosure to encourage natural foraging behaviors. The placement of a single water source and various enrichment items were similarly controlled by a daily random schedule, using the same division of the enclosure into nine areas.

Due to the husbandry standards of Alouatta Sanctuary and the social nature of spider monkeys, no attempts were made to randomize or equalize the duration or location of human interaction during data collection. To account for this, human presence or absence and human approaches and interactions were recorded during video analysis (Appendix B).

Video Data Collection

Sixty-five hours (*N* = 130 30-minute videos) of video data was collected in two-hour segments between 8:00 and 10:00 PTY from August 28 to October 18, 2015. The trained staff and interns of Alouatta Sanctuary (including the principal investigator) operated the video camera. To ensure a complete and constant view of the entire enclosure for each data collection period, the video camera was always placed in the same location, raised 3.5-meters off the ground. A data sheet was also kept to record the date, weather, and exact time recording started/ended; areas where enrichment, feeding basket(s), and water source were placed, and any additional notes (mainly regarding natural changes/destruction to the enclosure by the subject) (see Appendix C). If data could not be collected on any given day, an explanation was noted.

The researchers were instructed to verbally say the date and time immediately after starting the video camera, as well as record relevant information on the data sheet. Video recordings began before entering the enclosure to distribute food, enrichment, and water each morning (prior to, or exactly at 08:00 PTY).

Video Data Analysis

The collected two-hour video segments were divided into 30-minute focal samples (N = 130; 8:00-8:30, 8:30-9:00, 9:00-9:30, 9:30-10:00); of these focal samples, a 25% representive sample was randomly selected for coding and analyses (*n* = 33). Measures were taken to ensure the sample was standardized across time of day (7 – 9 videos were coded for each 30-minute interval). Video data was discarded if (1) the video camera was set up in a novel location and/or the entire enclosure was not in view (*n* = 1) or (2) the video recording was not of sufficient quality to describe the necessary elements of Luna's location, behavior, and/or locomotive/postural modes (*n* = 4).

Video data was analyzed by the principal investigator using a combination of derived and modified ethograms (see Appendix B). Recorded data points consisted of the point's timestamp, duration, vertical area, substrate in use, movement/non-movement state, positional/postural mode in use, simultaneously exhibited behaviors, the presence or absence of humans, and ad libitum notes (Appendix D). The enclosure's vertical space was divided into three areas for analysis: the triangular top and two rectangular areas (equally dividing the enclosure's base) (Appendix E). Data was initially recorded on physical data sheets (Appendix F) and later transcribed and compiled in Microsoft Excel.

Reliability. To demonstrate video coder agreement and ethogram reliability, interobserver reliability was conducted by comparing data from independent coders (the principal investigator, JF, and a second coder, JM). An agreement of 100% was obtained for durations of area use, 95% for use of substrate, 95% for movement/non-movement states, and 80% for positional/postural modes.

Results

In total, 33 30-minute focal sampled videos were coded, equating to 16.83 total hours of analyzed video. The data collected from this sample consisted of 6,202 data points, averaging 9.77 seconds in length (*SD* = 42.72; minimum = 1, maximum = 1560). All statistical analyses were conducted in IBM SPSS; for these analyses, each data point was rounded to the nearest second in duration and transformed so each second of analyzed video was represented as an individual event (*N* = 60,597 events).

Hypothesis 1) Vertical Space Use

It was hypothesized Luna would spend unequal amounts of time in each vertical area of the enclosure, predicting she would spend the most amount of time in the highest positions of the enclosure (Area 3). To test this hypothesis, a chi-squared goodness of fit test was conducted to compare the observed use of the three enclosure areas to the expected proportions of use, manipulated to represent the relative size of each enclosure area (Areas 1 and 2: 40%, Area 3: 20%). Significant deviation from the expected proportions was found, $\chi^2(2) = 996.28, p < .001$. This hypothesis was partially supported; Luna differentially utilized her enclosure space as hypothesized but did not utilize the individual spaces as predicted. Luna utilized Area 1 the most and Area 3 the least (see Table and Figure 1).

Table 1

Observed and Expected Vertical Space Use (Hypothesis 1)

Vertical Space	Observed Frequencies	Expected Proportions	Expected Frequencies
Area 1	27668	0.40	24232.8
Area 2	23164	0.40	24232.8
Area 3	9750	0.20	12116.4

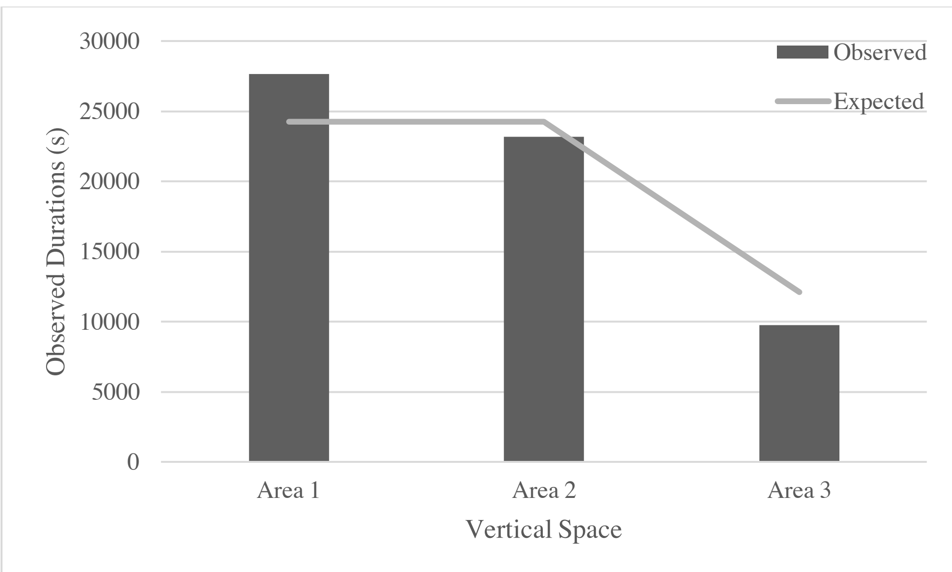


Figure 1. Observed and expected vertical space use (hypothesis 1).

To further investigate Luna's use of the enclosure, the ground was added to this analysis as another vertical area. With this additional area, it was hypothesized Luna's increased use of Area 1 would be explained through her use of the ground. To test this hypothesis, a chi-squared goodness of fit test was conducted to compare the observed use of the four enclosure areas to the expected proportions of use, manipulated to represent the relative size of each enclosure area (the ground: 2%, Area 1: 39%, Area 2: 42%, Area 3: 17%). Significant deviation from the expected proportions was found, $\chi^2(3) = 659.77$, $p < .001$. This hypothesis was partially supported;

whereas part of Luna's use of Area 1 was due to her use of the ground, Area 1 was still utilized much more than the other two enclosure spaces (see Table and Figure 1.1).

Table 1.1

Observed and Expected Use of Vertical Space (inclusive of the ground).

Vertical Space	Observed Frequencies	Expected Proportions	Expected Frequencies
Ground	1684	0.02	1211.6
Area 1	26002	0.39	23627.0
Area 2	23146	0.42	25444.4
Area 3	9750	0.17	10298.9

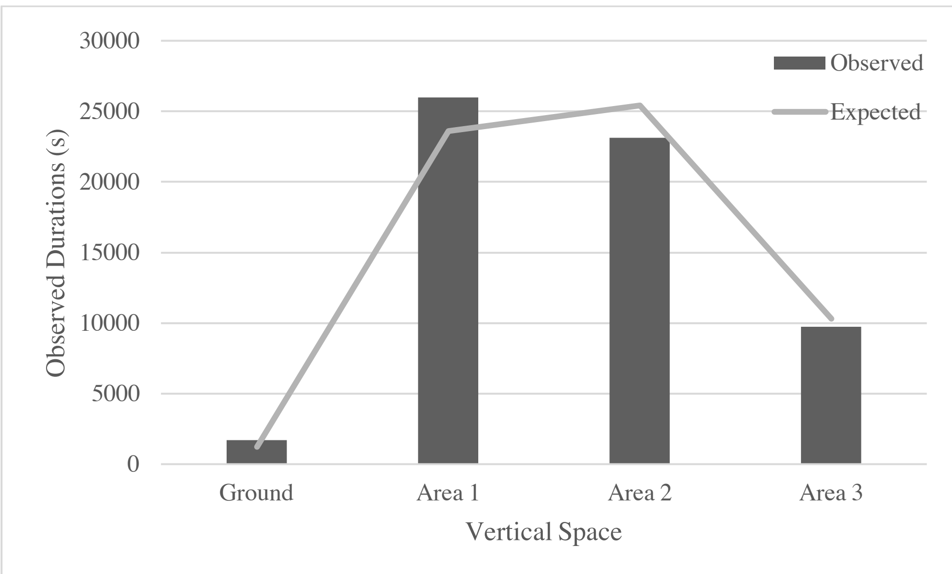


Figure 1.1. Observed and expected use of vertical space inclusive of the ground.

Hypothesis 2) Locomotive Modes

It was hypothesized that Luna would use semi-brachiation and clamber more than any other locomotive mode. To investigate this hypothesis, a chi-squared goodness of fit test was conducted to compare the observed frequencies of locomotive modes over all states of movement to the expected frequencies (chance or equal frequencies of each locomotive mode). Significant deviation from the expected frequencies was found, $\chi^2(4) = 9408.69$, $p < .001$. Partial support for this hypothesis was found; Luna used clamber and quadrupedal modes most when in locomotion rather than the predicted clamber and semi-brachiation (see Table and Figure 2).

Table 2

Observed and Expected Use of Locomotive Modes (Hypothesis 2)

Locomotive Mode	Observed Frequencies of Use	Expected Frequency
Bipedal	133	2883.40
Quadrupedal	4920	2883.40
Clamber	5819	2883.40
Semi-Brachiation	3244	2883.40
Leap	301	2883.40

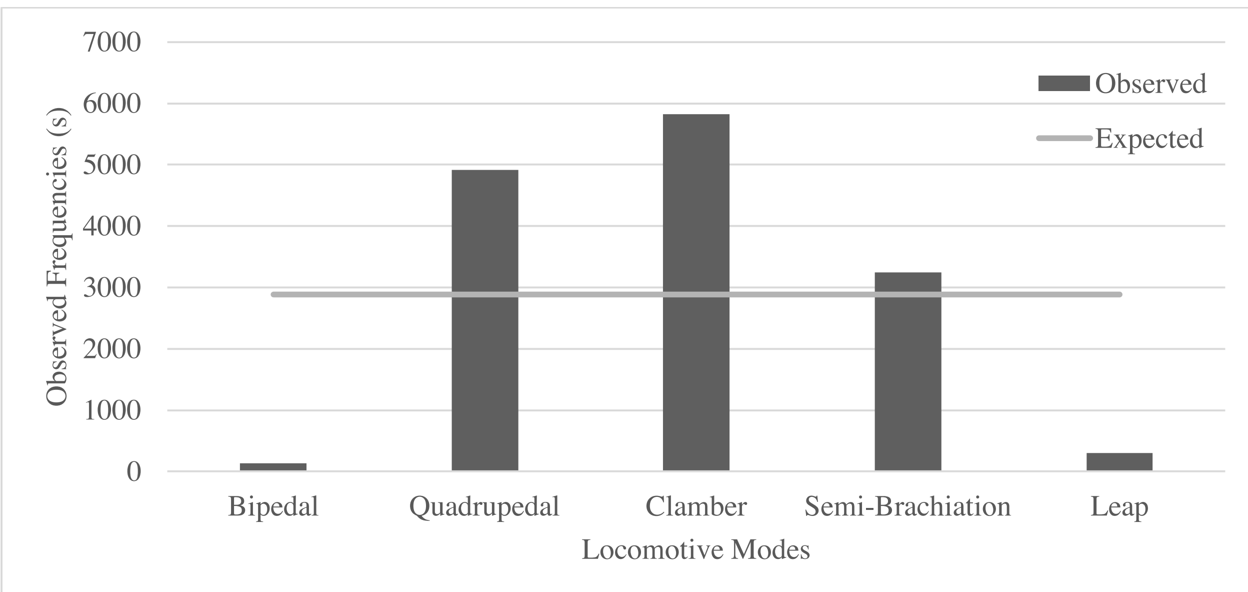


Figure 2. Observed and expected use of locomotive modes (hypothesis 2).

Hypothesis 3) Locomotive Modes and Stable Substrates

It was hypothesized Luna would move quadrupedally when on stable, relatively large substrates. To investigate this hypothesis, a chi-squared goodness of fit test was conducted to compare the observed frequency of locomotive mode use on branching and the ground to the expected frequencies (chance or equal frequencies of each locomotive mode on each substrate type). Significant deviation from the expected frequencies was found, branching: $\chi^2(7) = 11326.75, p < .001$; ground: $\chi^2(7) = 4913.02, p < .001$. This hypothesis was supported; Luna did locomote in a quadrupedal manner most often when on branching and the ground (see Table and Figure 3).

Table 3

Observed and Expected Use of Locomotive Modes on Branching and the Ground (Hypothesis 3)

Locomotive Mode	Branching Observed	Branching Expected	Ground Observed	Ground Expected
Bipedal	31	888.9	25	114.9
Quadrupedal	2808	888.9	817	114.9
Clamber	2235	888.9	31	114.9
Semi-Brachiation	1865	888.9	5	114.9
Leap	172	888.9	23	114.9
Rest	0	888.9	0	114.9
Hang	0	888.9	0	114.9
Other	0	888.9	18	114.9

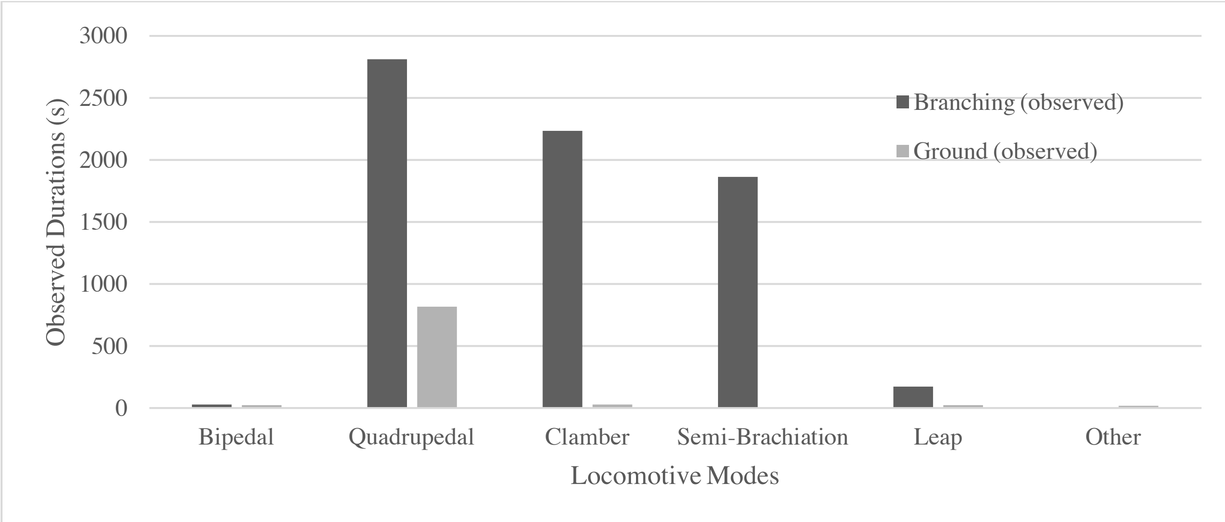


Figure 3. Observed use of locomotive modes on branching and the ground (hypothesis 3).

Hypothesis 4) Locomotive and Postural Modes and Substrate Use

It was hypothesized Luna would utilize suspensory modes (semi-brachiation and hang) most when on unstable substrates. To investigate this hypothesis, a chi-squared goodness of fit test was conducted to compare the observed frequency of postural/locomotive mode use on rope substrates to the expected frequencies (chance or equal frequencies of each postural/positional mode on rope). Significant deviation from the expected frequencies was found, postural: $\chi^2(7)= 4305.59$, $p < .001$; positional/locomotive: $\chi^2(7)= 3582.90$, $p < .001$. This hypothesis was supported; when on rope substrates, Luna most utilized semi-brachiation when locomoting, and hang when not in movement (see Table and Figure 4).

Table 4

Observed and Expected Use of Locomotive and Postural Modes on Rope (Hypothesis 4)

Modes	Locomotive Observed	Locomotive Expected	Postural Observed	Postural Expected
Bipedal	4	260.8	7	221.6
Quadrupedal	541	260.8	147	221.6
Clamber	603	260.8	2	221.6
Semi-Brachiation	906	260.8	0	221.6
Leap	32	260.8	0	221.6
Other	0	260.8	8	221.6
Rest	0	260.8	680	221.6
Hang	0	260.8	929	221.6

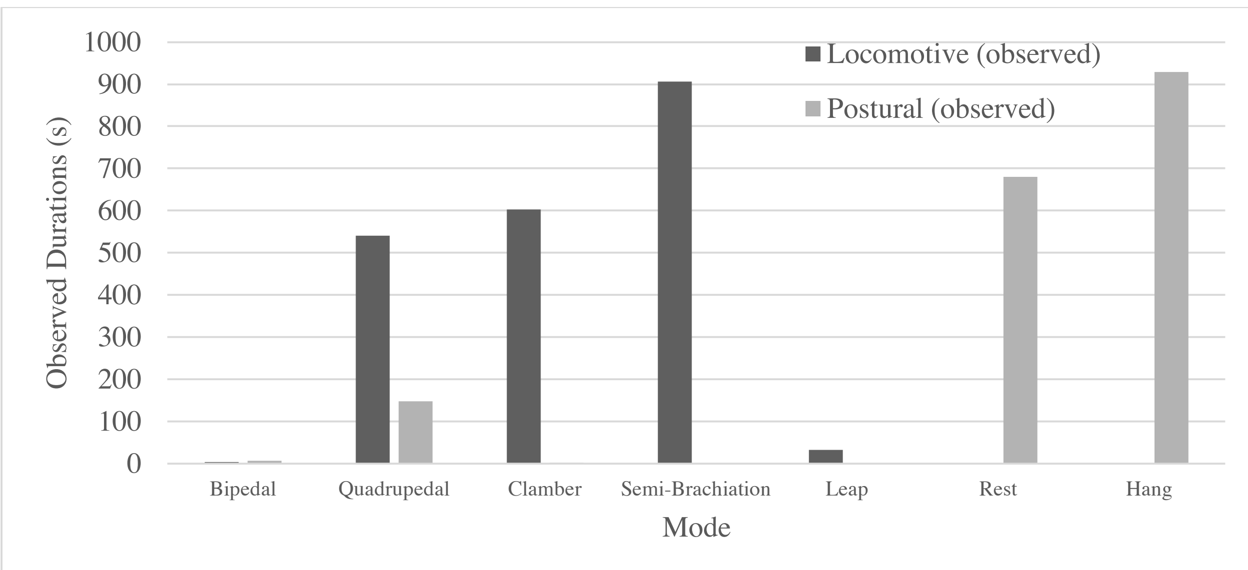


Figure 4. Observed use of locomotive and postural modes on rope (hypothesis 4).

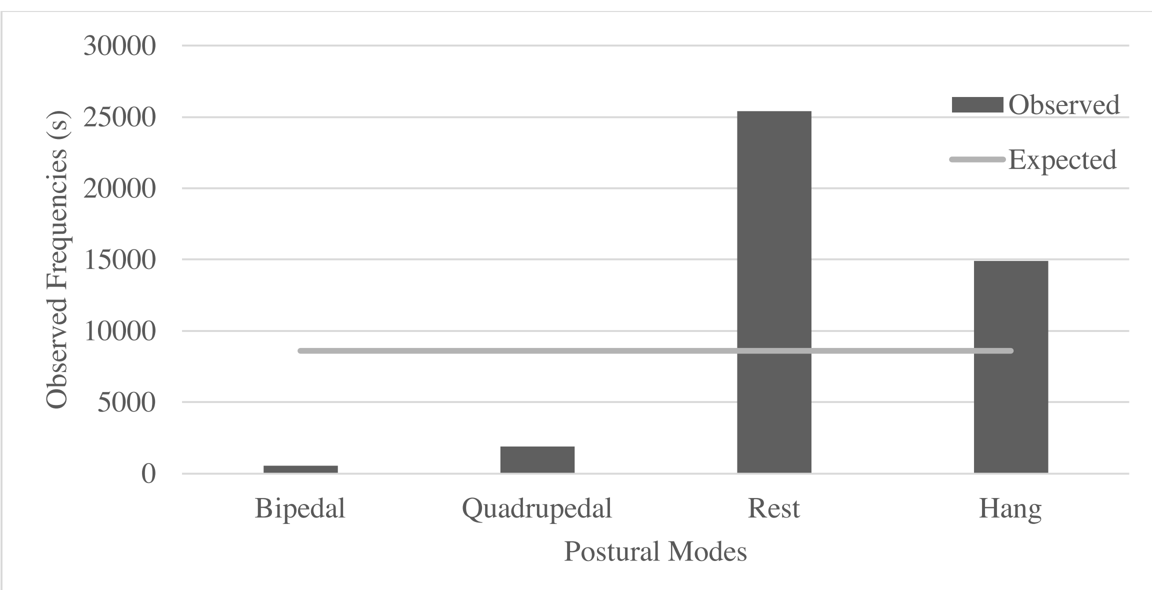
Hypothesis 5) Postural Modes

It was hypothesized Luna would utilize hanging suspensory modes and resting modes most commonly when not in motion. To investigate this hypothesis, a chi-squared goodness of fit test was conducted to compare the observed frequency of postural mode use across non-movement states to the expected frequencies (chance or equal frequencies of each postural mode). Significant deviation from the expected frequencies was found, $\chi^2(4) = 48607.60, p < .001$. This hypothesis was supported; when stationary Luna most utilized resting and hanging suspensory modes (see Table and Figure 5).

Table 5

Observed and Expected Use of Postural Modes (Hypothesis 5)

Postural Modes	Observed Frequencies of Use	Expected Frequencies
Bipedal	538	5372.0
Quadrupedal	1900	5372.0
Rest	25414	5372.0
Hang	14925	5372.0
Other	78	5372.0



Graph 5. Observed and expected use of postural modes (hypothesis 5).

Hypothesis 6) Activity Rate

It was hypothesized Luna's rates of activity/movement would increase over time as she rehabilitated towards release. To investigate this hypothesis, a Pearson correlation was calculated to examine the relationships between the focal sample's date and recorded rates of movement states. The relationship between the sample's date and Luna's recorded rates of movement was not significant (r (28) = -0.34, p > .05). No support for this hypothesis was found. However, while not statistically significant, Luna's observed states of movement weakly decreased over time (see Figure 6).

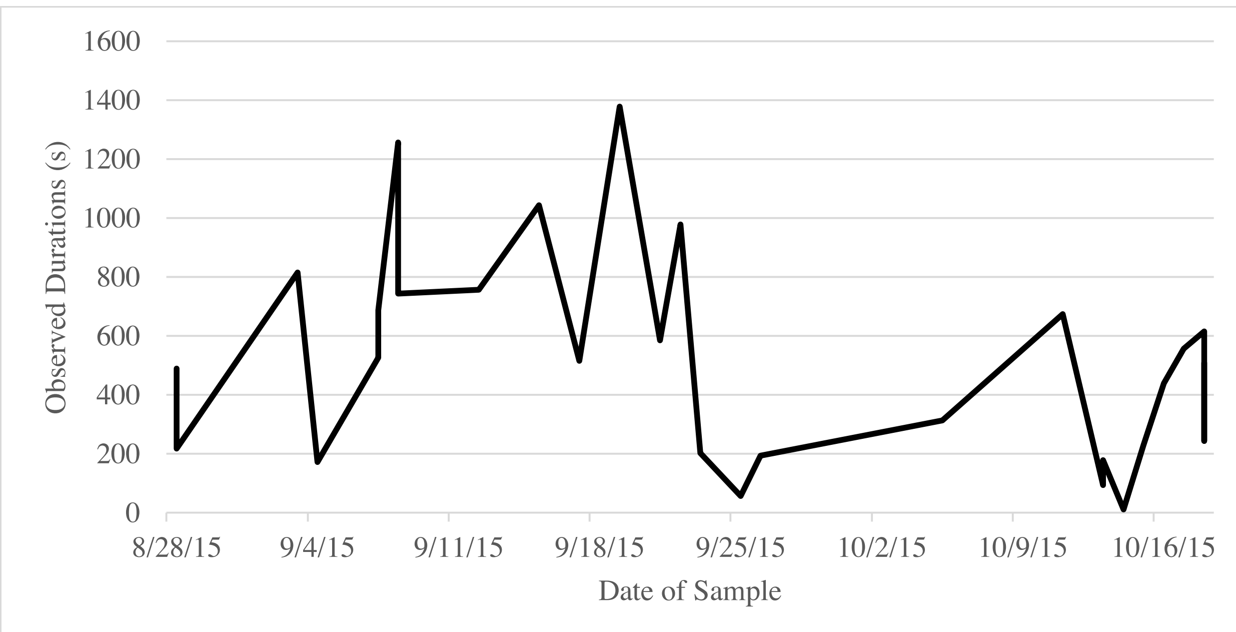


Figure 6. Observed durations of movement over time.

Hypothesis 7) Effects of Human Caregivers

It was hypothesized Luna would differentially utilize her enclosure space with and without the presence of humans. To investigate this hypothesis, a chi-squared goodness of fit test was conducted to compare the observed use of all enclosure areas with and without humans present in the enclosure with the expected proportions of use (manipulated to represent the relative size of each enclosure area; Areas 1 and 2: 40%, Area 3: 20%). Significant deviations from the expected frequencies were found, humans present: $\chi^2(2)= 2545.07, p < .001$, humans absent: $\chi^2(2)= 933.24, p < .001$. This hypothesis was supported; Luna differentially utilized her space with and without the presence of humans, most utilizing Area 1 with humans present and Area 2 when not present (see Table and Figure 7). It is worth noting, this analysis would be better represented by a Mann-Whitney *U* test (otherwise known as the nonparametric equivalent of an independent *t* test), but this nominal data does not meet the ordinal assumptions of the test.

Table 7

Observed and Expected Vertical Use With and Without the Presence of Humans (Hypothesis 6)

Condition	Vertical Area	Observed Frequencies of Use	Expected Proportion	Expected Frequencies
Humans Present	Area 1	25923	0.40	20824.4
	Area 2	19221	0.40	20824.4
	Area 3	6917	0.20	10412.2
Humans Absent	Area 1	1745	0.40	3052.0
	Area 2	3943	0.40	3052.0
	Area 3	1942	0.20	1526.0

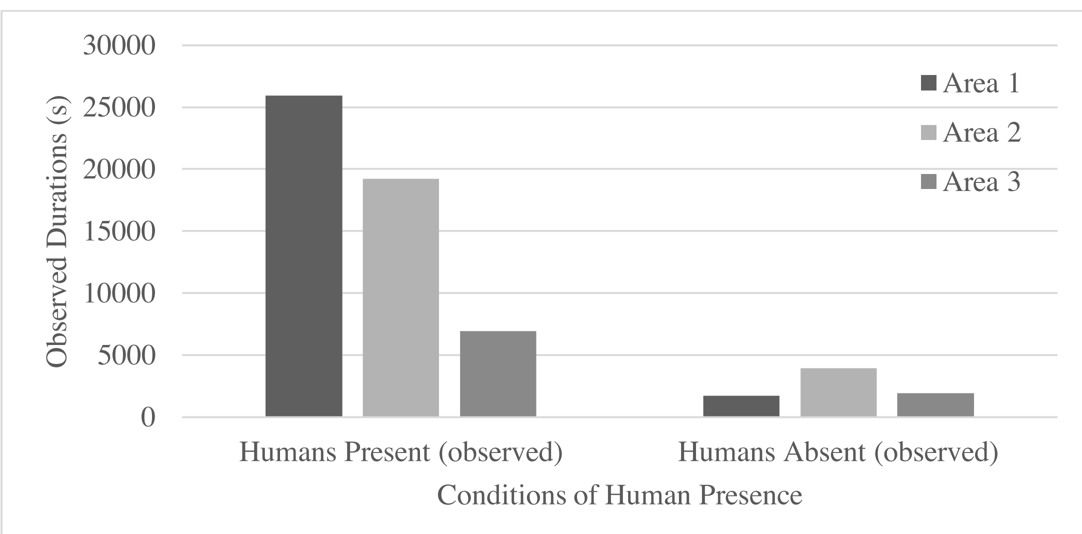


Figure 7. Observed vertical space use with and without the presence of humans (hypothesis 6).

Hypothesis 8) Human Caregiver Interactions

It was hypothesized the association rate between humans and Luna would decrease over time. To investigate this hypothesis, a Pearson correlation was conducted to investigate the relationship between time spent associating with humans and the date. No significant relationships were found; human approach and date: $r\ (28) = -0.22$, $p > .05$; human interactions and date: $r\ (28) = -0.16$, $p > .05$; total human associations and date: $r\ (28) = -0.19$, $p > .05$. This hypothesis was not supported. The association rate between humans and Luna did not change over time (see Figure 8).

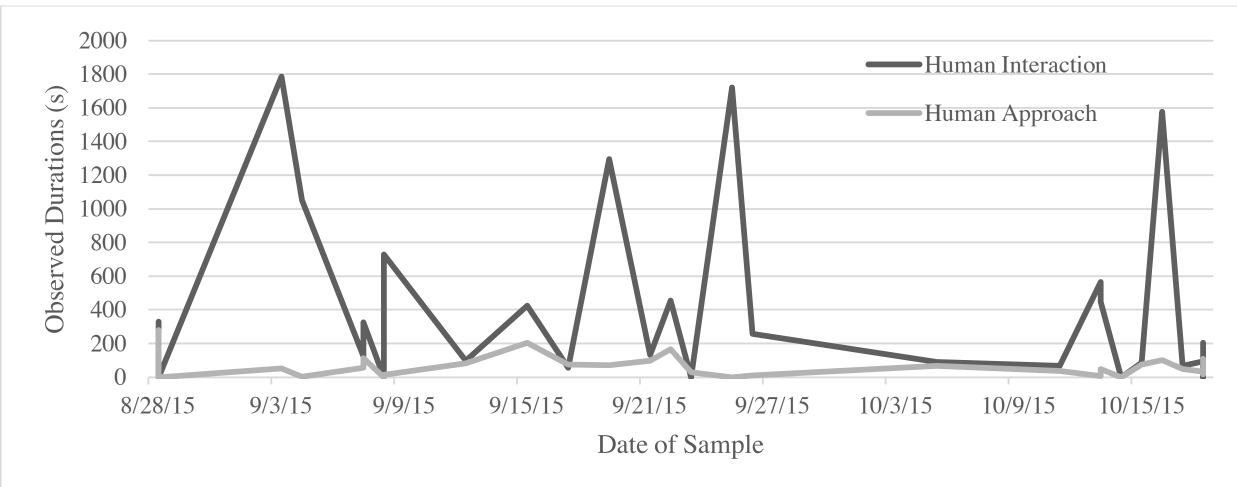


Figure 8. Human interactions and human approaches across days of collected data.

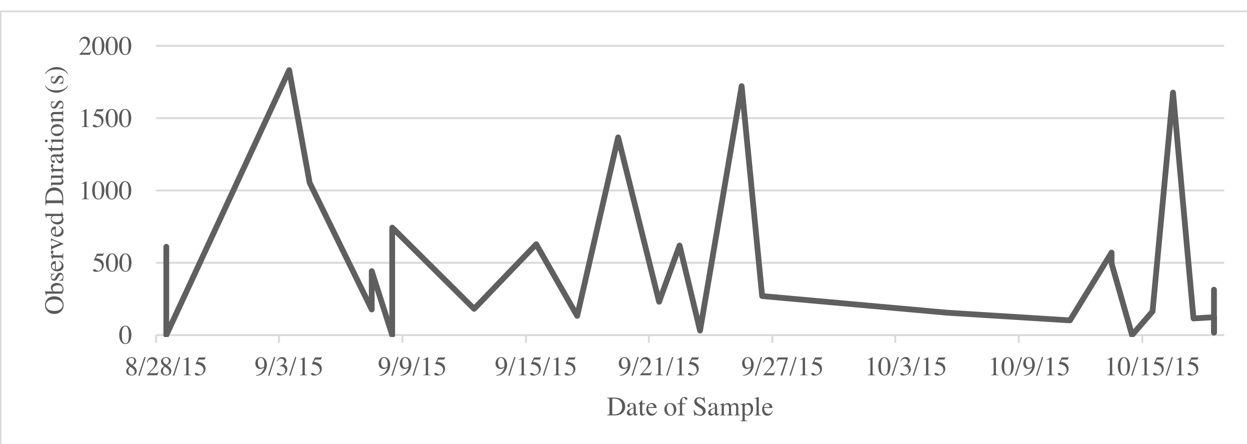


Figure 9. All human associations (combined interactions and approaches) across days of collected data.

Discussion

Use of Species-Typical Locomotive Modes

Across all wild investigations of spider monkey locomotion it has been clearly demonstrated individuals move about the canopy to obtain vital resources using a highly adaptive form of semi-brachiation; spider monkeys use this mode and other suspensory modes most overall (Cant, Youlatos, & Rose, 2001; Youlatos, 2002, 2008). However, Luna deviates from this known pattern; Luna most often utilized quadrupedalism and clamber (hypothesis 2). This suggests the enclosure's design did not assist Luna in utilizing spider monkey-typical rates of brachiation, and therefore might be inhibiting her ability to demonstrate normal parameters indicating release readiness.

Cant et al. (2001) found wild populations to most commonly display clamber when utilizing smaller substrates (< 2 cm), brachiation on medium-sized and flexible substrates (2-5 cm), and quadrupedalism most commonly on large and stable substrates (5-10 cm). Luna demonstrated similar use of substrates and correlated locomotive modes (evident in hypotheses three and four); she most commonly utilized quadrupedalism on stable branching and semi-brachiation on unstable rope (relatively thinner than the available branching). Furthermore, post-hoc chi-squared goodness of fit analyses found Luna most utilized clamber when on the relatively thinnest substrate, chain-link caging, in her enclosure ($\chi^2(2) = 4776.52, p < .001$). Luna most utilized clamber and quadrupedalism over semi-brachiation, yet she distributed her modes per substrate similarly to wild populations. Combined, these results might allude to unequal distributions of substrate type in the enclosure. Without doubt, chain-link caging was the most available substrate in the enclosure, without it the enclosure would not have structure; because this was the most available substrate and clamber was most utilized on the thinnest of substrates by both Luna and wild populations, it is reasonable to conclude Luna's heightened usage of clamber over all other modes is nothing more than a byproduct of the overabundance of wire caging available.

It could also be the case, when designing this particular enclosure with limited resources in the Panamanian jungle, care was taken to equally represent large and small width substrates (where clamber and quadrupedalism are most utilized) while middle-most width substrates were overlooked (where semi-brachiation is most utilized). This would further support the evidence of misrepresentation of substrate proportions. While these limited resources may be confounding to final analyses, they have not been viewed as a limitation of this study. These financial and structural resources best represent those available when attempting to rehabilitate primates in a wild setting, and therefore aid in making these findings applicable to other rehabilitation sites. Experimentally, it might be more appealing to design an enclosure where substrates of specified flexibility and width are proportionately or equally represented and precisely measured. It is these results, derived from limited resources, that are most generalizable to other rehabilitation sites across Central and South America.

When known wild rates of locomotive modes utilized on substrate type are considered with Luna's use of modes and substrates, it can be concluded Luna, herself, is not lacking the *capability* to display species-normal rates of semi-brachiation, but rather she has not been given the *ability* to display such rates. These are important variables to consider when assessing species-normative rates of both captive and rehabilitating primates; there is a profound difference between simply resembling known wild population rates and resembling proportional distributions of these rates across ecological variables (such as locomotive mode per substrate type). Labeling Luna as unqualified for re-introduction because she does not display semi-brachiation at absolute rates similar to wild individuals does not accurately characterize her ability to locomote in species-typical ways. She may be able to obtain vital resources for independent survival if given identical ("wild") substrate types and distributions.

Use of Vertical Enclosure Space

Wild populations of spider monkeys are known to most heavily use the upper-most positions of the canopy (Di Fiore et al., 2011; Wolfheim, 1983; Youlatos, 2002). Knowing this, it was expected Luna would show similar patterns of vertical space use, but evidence of the opposite was found (hypothesis one). Luna most utilized Area 1 and the ground (the lowest spaces) over all other vertical spaces, and utilized the ground much more than would be expected for a wild population who relatively never comes to the ground except for extremely valuable mineral resources (Di Fiore et al., 2001). Further, wild populations forced to use lower canopy positions are at increased risk of human hunting (Chapman et al., 1989; Cowlishaw & Dunbar, 2000; Di Fiore et al., 2001; Oates, 1996). Therefore, these results are concerning because, if re-introduced, Luna may be more inclined to utilize lower positions in the canopy and visibility to hunters, therefore decreasing her ability to survive independently.

Her minimal use of the upper-most enclosure areas might come from the abnormal design of Area 3. Seeing that this area is triangular in design and only a quarter of the size relative to the rest of the enclosures' base, this design might not be conducive for use. However, it is also possible that humans greatly influenced Luna's use of space.

Human effects. It is probable that humans greatly influenced Luna's observed use of space because spider monkeys are extremely social individuals and human caregivers were her main source of social interaction. This was evident through the analysis for hypothesis seven, where human presence resulted Luna to most utilize Area 1, while when humans were absent, Luna most utilized Area 2. Unfortunately, the observed absence of humans from the enclosure was relatively minimal. These results indicate human caregivers do have profound influence on

Luna's vertical space use, and such human-centered social interactions might have inhibited Luna from exhibiting species-typical use of vertical space, or, at least the use of space this investigation observed. Since it is clear human's location within the enclosure influenced Luna's use of vertical space, future husbandry standards might focus on elevating humans off the ground to encourage neotropical arboreal primates to utilize the upper-most portions of their naturalistic enclosures.

Similarly, Luna's associations with humans did not decrease over time as would be expected to promote independent survival (evident in the analysis of hypothesis eight). This provides further evidence that human caregivers governed by a rehabilitation methodology relying heavily on human contact had profound influence on Luna's behavior and may indicate her lack of preparedness for re-introduction. Categorizing Luna as unprepared for release after having *only* human caregivers as social partners is not surprising given that the "success" of this method with howler monkeys heavily relies on the understory co-exploration of bonded *conspecific* individuals (Schwartz et al., 2016). This suggests spider monkey rehabilitation methodology more conducive of success should include multiple conspecifics to reduce the necessity of human dependence; this is not surprising, as conspecific, social, group formation is a commonly cited best practice for primate rehabilitation (Baker, 2002). However, it's also possible the study period was not long enough to capture such a gradual decrease in human interaction. In relation to spider monkey life history, two and a half months may have not been a long enough period to see or expect such a decrease in human dependency.

Future Considerations for *Ateles spp.* Enclosure Designs

In sum, this evidence suggests the enclosure and husbandry standards at the sanctuary may be inhibiting Luna's acquisition of species-typical behavioral rates. Future enclosure designs should focus on distributing substrates with middle-most width and flexible properties to allow for species-typical displays of semi-brachiation. The literature on such enclosure designs does not discuss appropriate material for construction of the enclosure itself. This investigation found the wire caging to most determine Luna's overall use of locomotive modes, and this author assumes the same to be demonstrated with other individuals in differing enclosures. Perhaps, rather than focusing on thin, rigid, and confining wire structures, focus should shift to more durable and flexible material that can readily be used for locomotive purposes, but still prove inescapable. The overall shape of the enclosure should also be considered. While Campbell et al. (2015) suggest a triangular shape with few corners, to decrease the effects of conspecific gibbon aggression, designers should also consider the number of lateral walls, where semi-brachiation undoubtably cannot occur. To maximize her locomotive opportunities, Luna most likely had to clamber across the four large lateral walls of the enclosure's base, therefore increasing her overall rates of clamber. Furthermore, Luna's minimal use of the highest vertical space (Area 3) might be a byproduct of this space's shape and size (triangular and ¼ the size). When striving for species-typically elevated space use, these heightened spaces should entice such preferential rate of use. Furthermore, moving desired features (in Luna's case, human caregivers) to elevated positions within the enclosure might encourage species-typical vertical space use. Rather than designing conventionally shaped enclosures, more elaborate construction with multiple angled walls and flexible construction material could foster a more appropriate environment for readily displaying semi-brachiation and elevated space use.

Limitations and Future Considerations

This study's methodology took advantage of existing sanctuary husbandry schedules without alterations to collect video data (8:00AM – 10:00AM). While increasing practicality, this may have resulted in a biased sampling period. The sampling periods were constricted to human caregivers' presence (either in the enclosure or within the vicinity of the enclosure) because these caregivers were responsible for operating the video camera. To obtain a better examination of caregiver effects, this author suggests extending the sampling periods and study length to encompass a control condition where enclosure space use can be examined without the possibility of human effects. Further, to better assess enclosure space use, future studies should consider looking at enclosure space use throughout the entire day, potentially considering sleeping spaces. These 24-hour sampling periods could better contribute literature assessing species-typical daily activity rates and sleeping spaces.

Conclusions

1) The proportional representation of substrate types and size within the enclosure had the greatest effect on Luna's utilization of locomotive/postural modes.
2) Luna readily adapted her vertical space use to that of her human caregivers, using lower positions when humans were present and higher positions when humans were absent.
3) Future enclosure designs should focus on novel shapes and flexible structural material to promote species-typical behaviors across all possible areas.
4) Future studies should consider investigating space use throughout the entire 24-hour day, and, if interested in the effects of human caregivers, consider implementing a control period where humans are not present.

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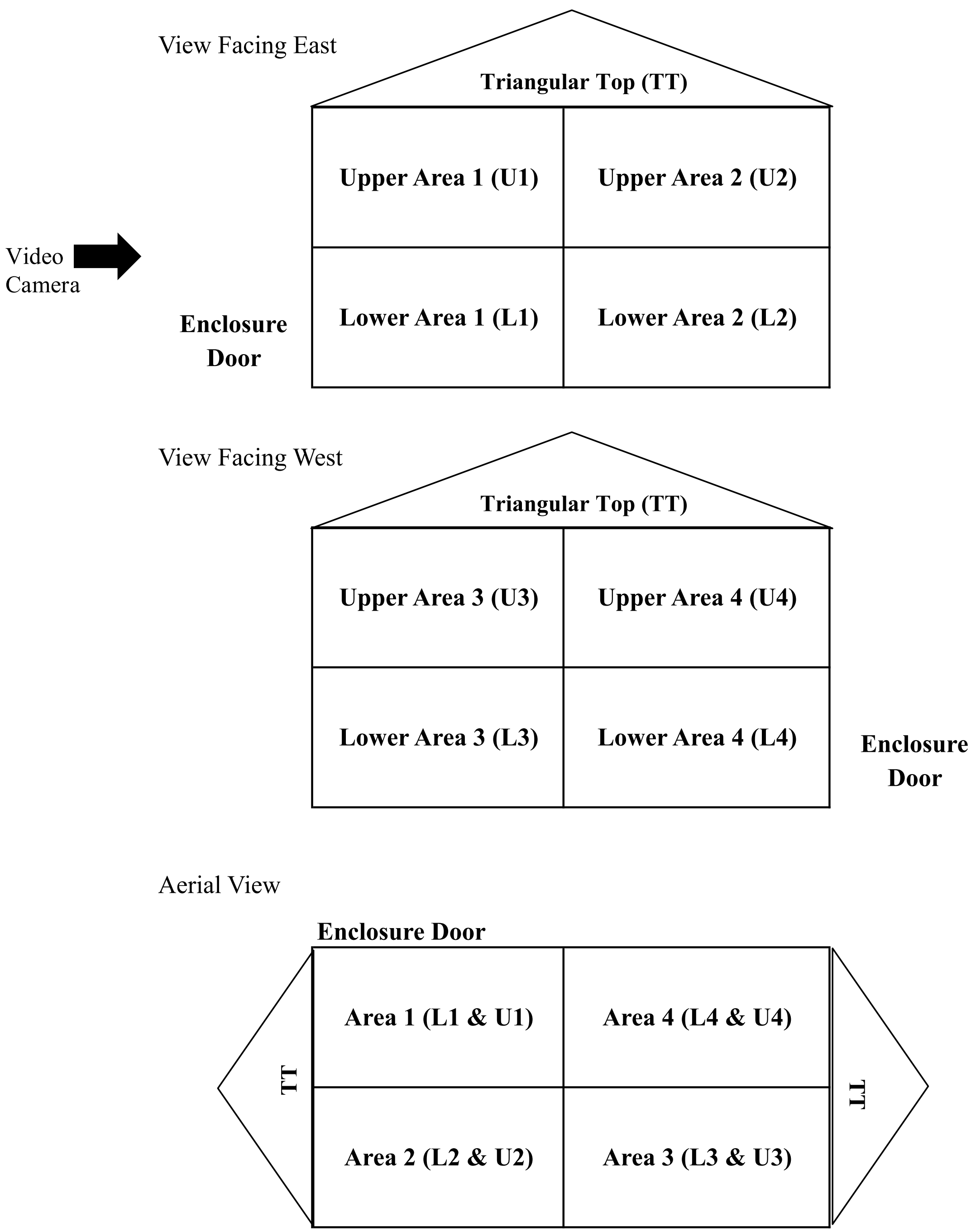
Appendix A

Division of Enclosure for Random Placement of Food Baskets, Water Source, and Enrichment

Diagram used at in the field to randomize placement of resources.



Appendix B

Ethogram

Substrate Types

Branching	B	Stable; natural, woody, material.
Rope	R	Unstable; store-bought, fabricated material; including all things suspended by rope (i.e. hammock, feeding baskets, swing, etc.)
Humans	HU	Caregivers
Ground	GR	Height of absolute zero
Wire Caging	CG	Fabricated metal material making up the outermost boundaries of enclosure
Chair	CH	Commercially fabricated place for humans to rest, made of plastic and metal.
Other	OT	Substrate not fitting in any other categorization: to be described in Notes

Indication of Movement or Non-movement States

Movement	MO, ✓	Progressively changing one's location in the enclosure
Non-Movement	NM, ✕	Behaviors that do not assist in the change one's use of space in the enclosure, thought to be stationary.

Locomotive Modes (modified from Youlatos, 2002, 2008)

Bipedalism	BI	Movement in an orthograde position supporting body weight on only one's feet, may be assisted by hands or tail on other supports
Quadrupedalism	Q	Movement in a pronograde position, on or above substrate, supporting body weight on all four of hands and feed across horizontal or sub horizontal supports.
Clamber	CL	Movement across multiple oriented supports in any direction, maintaining the body above or under supports, in either or neither ortho- or pronograde positions.
Semi-Brachiation	BR	Movement in suspended orthograde position below and along/across supports involving hand-over-hand locomotion, any number of contact points, may or may not involve tail-assistance
Leap and Drop	LEAP	Movement involving an airborne phase where no limbs contact a substrate, may or may not involve thrust
Other	OT	Movement not fitting in any category: to be described in Notes

Note. Coded only if Luna is first identified to be in movement.

Postural Modes (modified from Youlatos, 2002, 2008)

Bipedalism	BI	An orthograde position supporting body weight on only one's feet, may be assisted by hands or tail on other supports
Quadrupedalism	Q	A pronograde position, on or above substrate, supporting body weight on all four of hands and feed across horizontal or sub horizontal supports.
Rest	RE	Any type of body positioning where the body is not in movement. Includes, but not limited to, squat, sit, and lie.
Hang	H	Supporting one’s body weight with one’s tail, fore limbs, hind limbs, or any combination; positioning one’s body under one or multiple supports.
Other	OT	Supporting one's body weight in a way not fitting in any category: to be described in Notes

Note. Coded only if Luna is first identified to be in a non-movement state.

Behaviors

Human Interaction	HI	Engaging in contact with human caregivers.
Human Approach	HA	Movement directed towards human caregivers
Monkey Interaction	MI	Engaging in contact with another monkey. Note: other monkey name
Monkey Approach	MA	Movement directed toward another monkey. Note: other monkey name
Environmental Manipulation	EM	Engaging in physical contact with objects not related to holding one's body weight.
Feeding & Drinking	FE	Acquiring and eating food items, or drinking
Self-Grooming	SG	Bouts (10 or more seconds) of intentional scratching, picking, inspecting, biting, licking, or otherwise manipulation of one's own hair/skin.
Other	OT	Behavior not fitting in any category: to be described in Notes

Human Presence

Yes	Y	Human caretakers are in the enclosure with Luna.
No	N	Human caretakers are either out of frame or not in the enclosure with Luna.

Appendix C

Video Operator Data Collection Sheet

Date	Weather	Video On	Video Off	Enrich.	Water	Notes

Appendix D

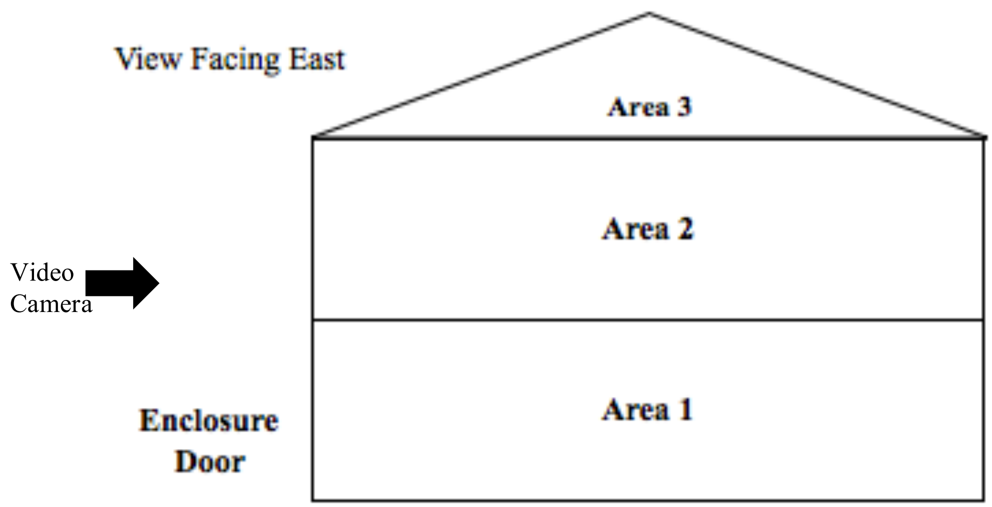
Sample Data Set

Date	Video O	Duratio	Are	Substrat	MO/NM	Behavio	Positio	HU?	Notes
Sept. 15	8:00:00 AM	3.00	2	NFB	MO		BR	N	
Sept. 15	8:00:00 AM	1.00	2	NFB	NM		TFH	N	
Sept. 15	8:00:00 AM	6.00	2	NFB	NM	EM	TH	N	ENRICHMENT
Sept. 15	8:00:00 AM	2.00	2	NFB	MO		VC	N	FOOD IN HAND
Sept. 15	8:00:00 AM	8.00	2	NFB	NM	FE	SIT	N	
Sept. 15	8:00:00 AM	2.00	2	NFB	MO		VC	N	FOOD IN MOUTH
Sept. 15	8:00:00 AM	7.00	2	NFB	MO		Q	N	FOOD IN MOUTH
Sept. 15	8:00:00 AM	7.00	2	NFB	NM	FE	BI	N	TAIL/FOREHAND ON CG
Sept. 15	8:00:00 AM	1.00	2	NFB	MO	HA	VC	N	
Sept. 15	8:00:00 AM	2.00	2	CG	MO	HA	VC	N	
Sept. 15	8:00:00 AM	2.00	2	CG	NM	HA	FH	N	
Sept. 15	8:00:00 AM	3.00	1	CG	MO	HA	VC	N	HU ENTERING
Sept. 15	8:00:00 AM	41.00	1	CG	NM	HI	TH	N	LUNA ON DOOR
Sept. 15	8:00:00 AM	1.00	1	CG, NFB	MO		SW	N	
Sept. 15	8:00:00 AM	4.00	1	CG	NM		SIT	N	
Sept. 15	8:00:00 AM	1.00	1	NFB, CG	MO	HA	SW	Y	HU ENTER
Sept. 15	8:00:00 AM	11.00	1	NFB, CG	NM		TH	Y	
Sept. 15	8:00:00 AM	8.00	1	NFB, CG	NM	HI	OT	Y	
Sept. 15	8:00:00 AM	6.00	1	HU	NM	HI	LIE	Y	
Sept. 15	8:00:00 AM	21.00	1	CG	NM	HA	SIT	Y	OTHER HU ENTER
Sept. 15	8:00:00 AM	4.00	1	CG	MO	HA	Q	Y	
Sept. 15	8:00:00 AM	2.00	1	NFB	MO	HA	Q	Y	
Sept. 15	8:00:00 AM	1.00	1	NFB	MO	HA	LEAP	Y	
Sept. 15	8:00:00 AM	5.00	1	HU	NM		QU	Y	
Sept. 15	8:00:00 AM	1.00	1	CH	NM	NV	NV	Y	
Sept. 15	8:00:00 AM	1.00	1	CH	MO		LEAP	Y	
Sept. 15	8:00:00 AM	15.00	1	NFB	NM		Q	Y	
Sept. 15	8:00:00 AM	2.00	1	NFB, R	NM		TFH	Y	
Sept. 15	8:00:00 AM	1.00	1	NFB	MO		LEAP	Y	
Sept. 15	8:00:00 AM	1.00	1	NFB	MO		SW	Y	
Sept. 15	8:00:00 AM	3.00	1	NFB	MO		Q	Y	
Sept. 15	8:00:00 AM	1.00	2	NFB	MO		VC	Y	
Sept. 15	8:00:00 AM	2.00	2	NFB	NM	EM	TFH	Y	R
Sept. 15	8:00:00 AM	35.00	2	NFB	NM	EM, FE	TH	Y	FOOD BASKET
Sept. 15	8:00:00 AM	3.00	2	NFB	NM	FE	THF	Y	
Sept. 15	8:00:00 AM	3.00	2	NFB	MO		VC	Y	
Sept. 15	8:00:00 AM	2.00	1	NFB	MO		VC	Y	
Sept. 15	8:00:00 AM	15.00	1	NFB	NM	HA	SIT	Y	

Appendix E

Area Division of Enclosure for Data Analysis

Diagram used to code "area" location during video coding.



Appendix F

Physical Data Sheet

DATE: ***TIME VIDEO ON:*** ***VIDEO TITLE:*** .

	Start Timestamp			Area	Substrate	MO?	Behavior	Postural/ Positional	HU Pres?	Notes
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