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PREPARING THE YUCATAN BLACK HOWLER MONKEY FOR ITS RETURN TO THE WILD: AN ASSESSMENT OF WILDTRACKS' APPROACH TO REHABILITATION AND REINTRODUCTION

A Thesis

Presented to

The Graduate Faculty

Central Washington University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

Primate Behavior & Ecology

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by

Blanca Ponce

May 2018

CENTRAL WASHINGTON UNIVERSITY

Graduate Studies

We hereby approve the thesis of

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Candidate for the degree of Master of Science

APPROVED FOR THE GRADUATE FACULTY

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Dean of Graduate Studies

ABSTRACT

PREPARING THE YUCATAN BLACK HOWLER MONKEY FOR ITS RETURN TO THE WILD: AN ASSESSMENT OF WILDTRACKS' APPROACH TO REHABILITATION AND REINTRODUCTION

by

Blanca Ponce

May 2018

Nearly half of non-human primates are in danger of extinction due to the negative impact of anthropogenic activities. Among the species most negatively affected is the family Atelidae (Di Fiore, Link, & Campbell, 2011). For this reason, non-human primates remain a central focus in global conservation efforts. Some of these efforts include welfare-based rehabilitation, re-introduction, and habitat preservation (Guy et al., 2014). Re-introduction projects have contributed significantly to conservation efforts, improved the lives of individual organism, promoted community education, and conservation values (Baker, 2002). However, Seddon et al. (2007) reveals that often, very little development and post-release monitoring goes into poorly run projects and many fail to establish viable populations (Griffith et al. 1989; Wolf et al. 1996). Re-introduction projects can include animals from diverse backgrounds, including individuals removed from the wild, zoo-raised animals, or animals that have been confiscated from the illegal pet trade (Guy et al., 2014). Because many of these animals' behaviors have been influenced by humans, many lack the social, behavioral, and ecological knowledge to survive in the wild and therefore must undergo an extensive rehabilitation process to ensure they develop

the appropriate behaviors necessary for their survival in the wild prior to being reintroduced (Cheyne et al., 2008). This study analyzes the effectiveness of the rehabilitation protocols for black howler monkeys (*A. pigra*) implemented by Wildtracks, a conservation NGO in Belize. In specific, my research is interested in documenting the behavioral differences across different stages in rehabilitation, that arguably these protocols produce, in comparison with the protocols outlined by the IUCN/SSC Re-Introduction Specialist Group. Wildtracks houses monkeys confiscated by the National Forest Department, rehabilitates them, and prepares them for release into the wild. This organization has had a successful rehabilitation program in place for ten years, demonstrating 95% post-release survival rates (P. Walker, personal communication, November 15, 2016). For this reason, Wildtracks serves as a good model to investigate pre-release training methods that result in behavior essential for positive release outcomes.

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CHAPTER I

INTRODUCTION

Nearly half of non-human primates are in danger of extinction. According to the International Union for Conservation of Nature Species Survival Commission's (IUCN/SSC) Primate Specialist Group (2008), "48% of non-human primates are vulnerable, endangered, or critically endangered" (as cited in Guy et al., 2014). Of this 48%, 40% are Neotropical primates (Mittermeier et al., 2009). Among the species most negatively affected by the impacts of anthropogenic activities is Atelidae (howler monkeys, spider monkeys, woolly monkeys, and muriquis; Di Fiore, Link, & Campbell, 2011). Monkeys are also highly desired by humans as pets; subsequently, there has been an intensification of illegally kept captive individuals (Cowlishaw & Dunbar, 2000; Dietz et al., 1994; Harrington, 2015). For this reason, non-human primates remain a central focus in global conservation efforts. Some of these efforts include welfare-based rehabilitation, re-introduction, and habitat preservation (Guy et al., 2014).

Re-introduction projects involving rehabilitated animals have offered many captive individuals a better quality of life (Kleiman et al., 1986) and contributed to the preservation of wildlife biodiversity through the re-establishment of viable populations of threatened species (Tutin et al., 2001). However, re-introduction goals also present complications for rehabilitation programs and the animals being re-introduced (Cheyne et al., 2008), especially when the animals have become accustomed to a captive lifestyle (Baker, 2002; Guy et al., 2014). Captive-raised animals (13%) are less likely to demonstrate positive release outcomes compared to translocated wild animals (31%) (Fischer & Lindenmayer, 2000; Jule et al., 2008, as cited by Schwartz et al., 2016, p. 261).

Rehabilitation is particularly challenging for animals that live in cohesive groups. Group living animals typically learn survival skills (e.g., foraging, predator recognition, social, and reproductive behavior) from watching their parents or conspecifics (Cheyne et al., 2007; Schwartz et al., 2016). In addition, species that spend a significant amount of time learning essential subsistence strategies from their parents demonstrate higher costs and spend more time in rehabilitation than other species (Cheyne, 2009). Animals raised in captivity that have not had the opportunity to grow with their natal group lack socially learned knowledge and therefore the skills necessary to survive in the wild (Cheyne, 2009). For example, a comparative study of captive raised lion tamarins and their wild born offspring indicated deficiencies in foraging and locomotor skills in the re-introduced parents but not their offspring (Stoinski et al., 2003). In addition, the parents were more likely to come down to the ground than their wild born offspring (Stoinski et al., 2003).

Further challenges are presented in rehabilitation programs when the rehabilitants being considered for reintroduction are orphaned infants of species that form strong familial or mother-infant bonds (Schwartz et al., 2016). Mother-infant social bonds play a key role in the development of infants, and for this reason, infants often suffer negative stress when they are removed from their mothers at an early age (Cheyne, 2009; Schwartz et al., 2016). Primates deprived of species-specific social interactions often suffer developmental delays and display stereotypic behaviors (e.g., pacing, over-grooming, coprophagy) (Cheyne 2006; Fritz & Fritz 1978; Nash et al. 1999, Schwartz et al., 2016). The subsequent release of inadequately socialized individuals demonstrating developmental abnormalities will inevitably fail (Yeager, 1997, as cited by Schwartz et al., 2016). For this reason, it may be most beneficial to encourage rehabilitants to form strong cohesive groups that can later be released together. In this way, inexperienced animals can take advantage of the benefits provided by group living including: higher numbers of individuals to warn against predators, increased identification of palatable food resources, and increased access to mates (Hamilton, 1971; Krebs et al., 1972; Wrangham, 1980; Whitehead, 1986). Studies reveal that rehabilitating and releasing individuals in groups has improved reintroduction outcomes in many different animals (Shier, 2006; Cheyne, 2009). For example, black-tailed prairie dogs (*Cynomys ludovicianus*) translocated with their families are five times more likely to survive and be reproductively successful than those translocated without families (Shier 2006). Similarly, juvenile mantled howlers (*Alouatta palliata*) undergoing pre-release training in groups spent less time approaching humans and increased their time in the canopy (Schwartz et al., 2016). Nonetheless, although methods used to achieve positive release outcomes exist, they are rarely reported in the literature (Guy et al., 2014), thus resulting in a major gap in the primate literature (Schwartz et al., 2016).

This study analyzes the effectiveness of the rehabilitation protocols for black howler monkeys (*A. pigra*) implemented by Wildtracks, a conservation NGO in Belize. In specific, my research is interested in documenting the behavioral differences across different stages in rehabilitation, that arguably these protocols produce, in comparison with the protocols outlined by the IUCN/SSC Re-Introduction Specialist Group. Wildtracks houses monkeys confiscated by the National Forest Department, rehabilitates them, and prepares them for release into the wild. This organization has had a successful rehabilitation program in place for ten years, demonstrating 95% post-release survival rates (P. Walker, personal communication, November 15, 2016). For this reason, Wildtracks serves as a good model to investigate pre-release training methods that result in behavior essential for positive release outcomes.

CHAPTER II

LITERATURE REVIEW

***Alouatta pigra*: Recognition as a Species and Taxonomic History**

Alouatta spp. are among the most well studied (Gavazzi et al., 2008; Pavelka & Knopff, 2004) and most widespread of all the Neotropical primates (Crockett & Eisenberg, 1987). *Alouatta* spp. can be found occupying ranges "from southern Veracruz State in Mexico to northern Argentina" (Cortés-Ortiz et al., 2015, p. 56). The genus *Alouatta* has received special attention from ecologists and ethologists due to their seed dispersal abilities, sedentary lifestyle and colonial habitats, as well as their unique morphological characteristics (large bodies and loud vocalizations) (Estrada & Coates, 1991; Smith, 1970). However, most of what is known about howler monkeys is derived from studies of two howler species: the Central American mantled howler (*Alouatta palliata*) and the South American red (*Alouatta seniculus*) (Gavazzi et al., 2008). Meanwhile, little is known about *A. pigra* (Pavelka & Knopff, 2004). Although the genus *Alouatta* has received a lot of attention in the scientific literature, relatively little is known about their taxonomy, and the recognition of individual species remains a topic of debate. For example, for many years, *A. pigra* (as well as all Mesoamerican howlers) was considered a subspecies of *A. palliata* (Gray, 1845; Cortés-Ortiz et al., 2015). It was not until Smith (1970) analyzed the morphological features (e.g., cranium, dentition, and hair) of two howler populations living sympatrically in Tabasco, Mexico that confirmed *A. palliata* and *A. pigra* were indeed two distinct species (as cited by Cortés-Ortiz et al., 2015). Horwich (1983) further supported the separation of *A. palliata* and *A. pigra* after noting morphological variance in male genitalia and group size. The testes of *A. pigra* males descend almost entirely during infancy (Horwich, 1983). In contrast, the testes of *A. palliata* do not descend until they have reached sub-adulthood

(Cortés-Ortiz et al.; 2015) (30-48 months) (Glander, 1980). Moreover, the vocal patterns of the two species are different (Whitehead, 1995). The separation of the two howler populations, *A. palliata* and *A. pigra*, was further reinforced by the identification of chromosomal differences and variance in male sex determinants. *A. palliata* has 2n=54 chromosomes and *A. pigra* has 2n=58 (Cortés-Ortiz et al., 2015). Moreover, in *A. palliata,* the sex of males is determined by the X1, X2, and Y sex chromosomes, whereas it is determined by the X1, X2, Y1, and Y2 sex chromosomes in *A. pigra* (Cortés-Ortiz et al., 2003; Steinberg, 2008). Sequencing of mitochondrial DNA solidified the separation of the two species by revealing that they both belonged to two monophyletic groups, separating 3 Ma, elevating *A. pigra* to species status (Cortés-Ortiz et al., 2003, 2015). Currently there are nine confirmed species of howlers: *A. palliata, A. pigra, A. seniculus, A. arctoidea, A. sara, A. macconnelli, A. guariba, A. belzebul, A. caraya* (Cortés-Ortiz et al., 2015). However, there are three other taxa believed to be distinct species, but taxonomists are hesitant to elevate *A. nigerrima, A. ululata,* and *A. discolor* to species status (Cortés-Ortiz et al., 2015, p. 55). Further analysis of their genetic makeup is essential to confirm their species status (Cortés-Ortiz et al., 2015). As further genetic and morphological studies of howlers increase during the next few years, we expect the taxonomic arrangement proposed by Cortez et al. (2015) to change significantly.

Alouatta pigra: Geographic Distribution, Ecology, and Conservation Status

Habitat

The black howler monkey (*A. pigra*), also known as “baboon” in Creole or “Saraguate” in Spanish, is one of the largest monkeys found throughout the Americas (Horwich & Lyon, 1990). *Alouatta pigra* occurs naturally in the Mesoamerican region with a distribution limited to parts of the southern Yucatan Peninsula of Mexico, western Guatemala, and Belize (Baumgarten & Williamson, 2007). In Belize, the “baboon” is most common along the Belize River, demonstrating a preference for low-lying tropical rainforest under 1000 ft. (300 m) above sea level, but can also be found in the foothills of the Mayan mountains (Horwich & Lyon, 1990). However, in areas lacking an appropriate habitat, howlers can be found living near urban areas in unsuitable habitats (Cuarón 1991, 1997; Marsh, 1999, 2001, 2002). They are extremely flexible in their behavior and diet allowing them to adapt well to changing environments and the ability to inhabit a variety of habitats (Marsh et al., 2008; Horwich & Lyon, 1990).

Home Range, Territoriality, and Group Size

The home range of *A. pigra* varies depending on troop size and availability of resources, but typically they inhabit small overlapping home ranges (Neville et al., 1988) between 3 to 25 acres (Horwich & Lyon, 1990). For this reason, *A. pigra* is not considered strictly territorial, but there is no consensus on the territoriality of all species of *Alouatta* (Cornick & Markowitz, 2002). It appears that they have established territories that they occupy year-round, and like many other primate species, they do not tolerate other groups in their immediate area (Horwich & Lyon, 1990; Carpenter, 1965). It is believed that howlers defend their territories from intruding troops using a set of loud vocalizations (Horwich & Gebhard, 1983; Horwich & Lyon, 1990). Because these howls are mostly performed at dusk and dawn, it is believed that they are utilized by howlers to promote spatial awareness and serve as a method to avoid conflict over resources or females (Kitchen et al., 2004; Horwich & Lyon, 1990). However, these calls can also be heard before it rains and when other animals are feeding, suggesting that spatial recognition may not be the chief function of howling behavior (Horwich & Lyon, 1990). *Alouatta pigra* lives in small groups that range from two to ten individuals (Horwich & Lyon, 1990). These numbers are small compared to the numbers of *A. palliata*, whose groups can range from 2-45 individuals (Crockett & Eisenberg, 1986). Troops are typically polygynous, meaning they generally have a single male living with multiple females and their young (Di Fiore et al., 2011). However, multi-male groups and solitary males living without a troop have been documented in the wild (Horwich & Lyon, 1990). Howler troops remain stable from year-to-year and individuals typically feed, sleep, and travel together. Occasionally, the troop will split up to feed, but later reform into the original troop (Horwich & Lyon, 1990). Based on what we know about howler group structure; group cohesion may be the key factor connected to the survival of *A. pigra*.

Morphology

Males (*A. pigra*) typically weigh an average of 11.4 kg, while females average 6.4 kg. On its own, the length of the body can be between 52 and 71 cm. Similar to spider monkeys (*Ateles* spp.), *A. pigra* possess a prehensile tail that is slightly longer than its body, averaging between 50 and 67 cm (Richardson, 2006). The prehensile tail serves as another limb that allows howlers to hang from their tails and is used to grab onto branches, facilitating travel through the canopy, and enabling them to harvest hard to reach food items (Di Fiore et al., 2011).

Vocalizations

One of the most unique characteristics of howler monkeys is their ability to produce one of the most powerful vocalizations in the Neotropics (Cortez et al. 2015) that can be heard from a mile away (Horwich & Lyon, 1990). These calls are produced using an elaborate set of throat structures, consisting of a pneumatized hyoid bone with a large hollow basihyal that serves as a resonating chamber (as cited by Cortez et al., 2015). Every howler species that has been studied exhibits two forms of loud calls: barks and roars (Altmann, 1959). In addition, Cortez et al. (2015) describes incipient forms of roaring and barking that are often observed at short range. Consequently, they are not classified as loud calls but are typically produced during long calling bouts (Cortez et al., 2015). The incipient form of roaring generally consists of short pulses that resemble a brusque popping noise (Altmann, 1959). In *A. pigra*, these incipient roars are not as common as in South American howlers and consist of short bursts of popping (described as an 'aw' or 'er' sound) (Baldwin & Baldwin, 1976) that are often emitted before a full roar. Another call emitted prior to a full roar in *A. pigra* is the incipient bark. The incipient bark has been described in *A. palliata* as an "unf unf unf" and a grunting sound in *A. pigra* (Kitchen DM unpubl. data; Kitchen pers. Obs.; as cited by Cortez et al., 2015). On the other hand, a full roar is characterized by high amplitude with a sound pressure level up to 90 dB at a 5-m distance (Whitehead, 1995). Other common features of a howler's roar are its low frequency and harshness (Cortez, et al.2015). However, these calls can vary between species. For example, while many South American species emit full, long roars with a long exhalatory and a short inhalatory phase, Central American species (*A. palliata* and *A. pigra*) only emit short continuous roars with one long exhalatory emission that typically lasts 2.2 seconds (that is at times preceded by a short inhalation), followed by a short low amplitude call (as cited by Cortez et al., 2015).

Aside from loud calls, howlers also contain a vast repertoire of soft calls that are often neglected in the literature and continue to be understudied. Hence, most of the information on these vocalizations is limited to studies on *A. palliata* and *A. caraya*. Soft calls discussed in the literature include contact calls, immature calls, and alarm calls. Contact calls are produced when group members wander too far from their group. These calls have been described as whimpers in *A. palliata* (Baldwin & Baldwin, 1976), cries (Calegaro-Marques & Bicca-Marques, 1997), and moo calls in *A. caraya* (Cunha & Byrne, 2013). All three calls have been observed in group progressions and stressful situations where the caller was observed away from the group. The moo call has been described as being representative of a true call and answer system in *A. caraya* (Byrne 2000; da Cunha & Byrne 2009) and is therefore thought to play a particularly important role in contact. However, further research is needed to fully understand the function of low amplitude calls of howlers (Cortez et al., 2015).

Diet

Howlers are assumed to be the most folivorous of all Neotropical primate communities (Eisenberg et al. 1972; Milton 1980) due to their dependence on leaves (Milton & McBee, 1983) and dental morphology. Howlers have molars with large shearing crests that are an adaptation for chewing leaves (Marsh et al., 2008). However, recent studies of the feeding ecology of *A. pigra* revealed that black howlers balance their diet by eating a variety of foods, and their diet is dependent on the availability of those preferred foods (Pavelka & Knopff, 2004). In addition, *A. pigra* is one of the only New World monkeys that includes mature leaves in its diet. Their dietary flexibility allows them to survive for extended periods of time on a strict leaf-based diet if leaves are all they have access to (Horwich & Lyon, 1990). This may explain their ability to inhabit a variety of habitats. However, mature leaves are clearly not their first choice. *A. pigra* prefers to eat a variety of flowers, fruits, petioles, seeds, moss, stems, twigs, termites (when available), and young new leaves, with lower concentrations of toxic tannins and alkaloids (Emmons et al., 1996; Silver et al., 1998, 2000; Ostro et al., 1999), that are less fibrous, thus making them easier to digest (Milton, 1979). Black howler monkeys at the Community Baboon Sanctuary in Belize have been best described as "as frugivorous as possible and folivorous as necessary" by Silver et al. (1998) (as cited by Pavelka & Knopff, 2004, p. 106). Howlers consume young and mature leaves year-round, however, their consumption of fruit is dependent on its abundance (Silver et al., 1998). Their dietary flexibility facilitates the colonization of new habitats, either naturally or through a human-led process (Silver et al., 1998), hence, making them good candidates for rehabilitation and reintroduction programs.

Activity

Behaviorally, the activity budget of *A. pigra* follows the typical *Alouatta* pattern (Pavelka & Knopff, 2004). Howler monkeys are known for being large, energy-minimizing leaf-eating monkeys, spending up to 70% of their time resting high in the tree tops, fermenting leaves in their large caecum (Horwich & Lyon, 1990; Marsh et al., 2008). Resting accounts for most of their daily activity, followed by feeding, locomotion, and social interactions (grooming and play) (Silver et al., 1998; Estrada et al., 1999; Pinto et al., 2003). Howler's elongated resting behavior is often correlated to their folivorous diet. Their energy minimizing lifestyle is thought to be a response to their consumption of low-quality leaves (Milton, 1980) that require extended periods of digestion and fermentation (Horwich & Lyon, 1990). However, other studies challenge this notion. Pavelka and Knopff (2004) found that *A. pigra* maintains this sedentary lifestyle even during times of high fruit availability, suggesting that diet is much more generalized in this species, whereas behavior is not, indicating some form of phylogenetic constraint.

Social Behavior

Howler troops are maintained using a combination of friendly and aggressive behaviors directed between and within troops (Horwich & Lyon, 1990). Nonetheless, affiliative behavior is rarely observed in *Alouatta*, and as a result, social relationships are considered weak (Di Fiore et al., 2011). Grooming is rarely observed in howlers despite it being a typical behavior of many primate species to maintain social bonds. When it is observed, it is usually conducted in a relaxed situation between individuals of the opposite sex that know each other well (Horwich & Lyon, 1990). Play behavior is a common phenomenon among mammals (Oliveira et al., 2003) and has been widely documented in every primate species studied (Burghardt, 2005). Nonetheless, play and its functions have not been well defined in the literature (Bekoff, 1997). Many authors have defined play as behavior without a clear function, while others characterize it as being voluntary, spontaneous, pleasurable, intentional, and exaggerated (Bekoff, 1997; Burghardt, 2005). In respect to the functionality of play, it has been proposed that play may serve diverse functions (e.g., improving motor and cognitive skills) for individuals of different species, sex, and age (Bekoff, 1997) and may play a critical role in the development and socialization of young animals (Baldwin & Baldwin, 1978). Play may provide young animals many social skills (e.g., sexual behavior, predator avoidance, maternal behavior, controlled aggression) that may be useful to the individual later in life. Play is common in young howlers. Often times, young howlers can be observed playing with themselves (feet, hands, tail) or with surrounding objects (leaves, twigs, fruit), but the most common form of play involves two or more individuals (wrestling, chasing) (Carpenter, 1934). In *A. pigra*, younger individuals typically chase and wrestle each other and display play faces (open mouth with their teeth showing), while making low-pitched play grunts. However, this phenomenon is not restricted to young monkeys, as adults will also wrestle and chase each other. Young sub-adult males have also been observed eliciting play from the dominant male as a strategy to extend their stay within the troop and avoid being forced, by the dominant male, to disperse (Horwich and Lyon, 1990). Nonetheless, in general, as individuals get older, play becomes more aggressive and begins to resemble more serious physical aggression. Hence, as individuals mature, play is less frequent (Carpenter, 1934). Like many ungulate species, *A. palliata* and *A. pigra* males have been observed engaging in exploratory behavior toward females in estrus. These exploratory behaviors include smelling the female's genitalia, urine, or vaginal discharge (Carpenter, 1934, Horwich, 1983). Another sexual behavior that appears to play an important role in signaling copulation is prolonged eye contact followed by rhythmic tonguing. This behavior appears specifically important to the female. Typically, a female will gaze at the male for a period of time and flick her tongue in a slow, but repetitive motion toward the male. However, rhythmic tonguing is not limited to females; these lingual gestures can be produced by either sex to signal copulation (Horwich & Lyon, 1990; Horwich, 1983; Carpenter, 1934). When threatened, adult males exhibit aggressive behaviors, which serve as a warning to their aggressors. Some of these behaviors include: howling, piloerection, raised and hunched shoulders, branch grasping, and scent marking (Horwich & Lyon, 1990). For example, when an intruding troop imposes on another group's territory, resident groups roar and chase the intruders back to their own territories. These confrontations are often followed by roaring bouts between the two groups. Like other animals, when threatened, howlers will also raise their hair to make them look bigger and more intimidating (piloerection). Piloerection is typically followed by the howler raising and hunching their shoulders, leaning forward and grasping a tree branch. Male howlers also convey an angry olfactory message to other males using a gland on their throat that leaves a scent after the male has rubbed his chest and throat on an object (Horwich & Lyon, 1990).

Black Howler Population in Belize & Conservation Status

In many areas of its range, the black howler monkey is rare and at risk of extinction (Horwich & Lyon, 1990). However, Belize is fortunate to have a healthy population of *A. pigra,* despite experiencing four catastrophic population crashes after devastating hurricanes swept through Bermudian Landing, Belize in 1931, 1954, and 1978 (Hartshorn, 1984; Bolin, 1981). In 1971, *A. pigra* faced another significant decline in its population after a yellow fever epidemic nearly wiped out the entire Central American howler population (Baldwin, 1976; Hartshorn, 1984). Together, the four events nearly extirpated local howler populations, reducing them to significantly low levels and changing the behavioral dynamics of the remaining troops (Baldwin, 1976; Bolin, 1981). However, howler populations recovered rapidly (James et al., 1997) and in some areas "population densities of up to 250 individuals per km^2 have been recorded" (Horwich & Lyon, 1990), demonstrating the resiliency of this species. Nonetheless, high population densities of *A. pigra* are generally found in protected areas (Marsh et al., 2008). Unfortunately, *A. pigra* is listed as "endangered" under the IUCN Red List and is expected to experience a 60% decline over the next three generations (30 years) due to rapid habitat decline, hunting for bush meat, and the pet trade (IUCN/SSC Primate Specialist Group, 2008). Young howlers are especially vulnerable to the illegal pet trade, as infants make appealing pets (Duarte-Quiroga & Estrada, 2003). Generally, howler monkeys can adapt well to fragmented environments (Pavelka & Knopff, 2004), and their generalized diets allow them to eat a variety of foods and inactive lifestyles do not require large home ranges (Horwich & Lyon, 1990). Nonetheless, much of the rainforest *A. pigra* inhabits has been cleared for agriculture and logging (Horwich & Lyon, 1990). Among the most affected is Guatemala, with only 26% of its forest cover remaining, followed by Mexico (28%) and Belize (59%) (Van Belle & Estrada, 2006). For this reason, habitat fragmentation is a major focus in primate conservation due to its increased pressure on individual species and communities. Many conservationists are working together with local communities to develop conservation strategies to prevent the destruction of our tropical rainforests and preserve the biodiversity of wild populations. One of these conservation strategies is species re-introduction (Baker, 2002).

Defining Welfare Based Primate Rehabilitation and Reintroduction for Conservation

The IUCN defines re-introduction as the "release of a taxon in an area from which it has been extirpated or become extinct" (Baker 2002). According to Kleiman (1989) humans have been reintroducing animals since the early 1900s, and although there is no clear documentation of the very first re-introduction, one of the earliest accounts has been traced back to 1907, when 15 American bison (*Bison bison*) were released into a reserve in Oklahoma (as cited by Seddon et al., 2007). However, the 1970s and 1980s led to an increase in recognition and helped solidify species re-introduction as a conservation strategy with the re-introduction of the Arabian oryx (*Oryx leucoryx*), golden lion tamarins (*Leontopithecus rosalia*), and peregrine falcons (*Falco peregrinus*) (Seddon et al., 2007). Re-introduction projects have contributed significantly to conservation efforts, improved the lives of individual organisms, promoted community education, and conservation values (Baker, 2002). However, little development or post-release monitoring is performed, particularly in poorly run projects, and many fail to establish viable populations (Griffith et al. 1989; Wolf et al. 1996) and have high post-release mortality (Baker, 2002; Seddon et al., 2007). For example, a review on animal reintroductions, "found that only 26% of the 116 projects assessed were deemed successful, failed re-introduction projects accounted for 27% failed, with the remaining 47% having unknown outcomes (Fischer & Lindenmayer, 2000 as cited by Guy et al. 2014, p. 140). Re-introduction projects can pose negative threats to wild populations and their natural ecosystem (Baker, 2002). For example, reintroduced animals habituated to humans can transmit diseases to wild populations if medical screening is not conducted prior to release. Such a problem arose with the reintroduction of hand-raised orangutans (*Pongo pygmaeus*) that were infected with tuberculosis (*Mycobacterium tuberculosis*) into an area with uninfected conspecifics (Jones, 1982). Regardless, wildlife restoration projects continued to increase globally (Seddon et al., 2007). As a result, the World Conservation Union's (IUCN) Species Survival Commission formed the Reintroduction Specialist Group (RSG) (Seddon et al., 2007; Stanley Price & Soorae, 2003). In 1992, the RSG launched their first workshop leading to the formulation of reintroduction guidelines (Seddon et al., 2007). These guidelines were meant to serve as a guide to ensure that practitioners were utilizing a "best practice model or ideal code of conduct" when re-introducing wild animals (Baker, 2002). However, many continue to question the potential of species re-introduction as a conservation strategy, as it is believed that many of its practitioners fail to implement the IUCN guidelines into their projects. For example, a recent review on welfare-based rehabilitation and reintroductions, found that of the "26 factors listed as being critical for rehabilitation and re-introduction, only ten were implemented in less than 50 % of primate rehabilitation projects" (Table 1; Guy et al., 2014, p. 142).

Table 1

'IUCN Guidelines and Other Crucial Factors Considered to Be Critical for Rehabilitation and Re-introduction'

Stages	**26 Factors**
Arrival	History collection as possible
	Quarantine
	Medical assessment
Group Formation	Behavioral assessment
	Genetic
	Behavior
	Compatibility
	Wild group size and composition
Training & Preparation	Assess release suitability
	Conspecific re-socialization
	Limit human contact
	Predator awareness training
	Natural food
	Natural enclosures
	Environmental enrichment
Pre-release Assessment	Release site
	Observe behavior and identify problems
	Health/disease screening
Pre-release	Acclimatization to the release site
	Natural food in pre-release enclosure
	Food provided in a way to develop foraging skills
	Further limit human contact
Release	Soft release
	Transport plan
Post-release	Long term monitoring (>1 year)
	Periodic assessment of success and success criteria

Source. Baker (2002) as cited by Guy et al., (2014), p. 142.

Re-introduction projects can include species with diverse backgrounds, including individuals removed from the wild, zoo-raised animals, or animals that have been confiscated from the illegal pet trade (Guy et al., 2014). Others have been directly affected by human activities such as clearing land for agriculture and hunting for the bush meat trade (Yeager, 1997; Goossens et al., 2005; Wimberger et al., 2010). Because humans have influenced the behavior of these animals, many lack the social, behavioral, and ecological knowledge to survive in the wild, and therefore must undergo an extensive rehabilitation process to ensure that individuals develop the appropriate behaviors necessary for their survival in the wild prior to being reintroduced (Cheyne et al., 2008). These behaviors include critical skills such as group formation, foraging abilities, response to predators, little to no human dependency, and a behavioral repertoire similar to their wild conspecifics (Guy et al., 2014).

The rehabilitation and release of primates as a conservation strategy has not been well assessed in the primate literature (Guy et al., 2014). The IUCN defines rescue and welfare rehabilitation as "the movement of wild primates from one area to another to rescue them from a hazardous situation or to resolve human-primate conflicts, or the release of captive primates, such as orphaned or surplus animals, to attempt to improve their welfare" (Baker 2002), but does not condone its use as a conservation strategy. For this reason, the IUCN does not specifically cover it under their guidelines or list it as a reintroduction or conservation approach because its main objective is "animal welfare" and not conservation (Baker, 2002; Guy, 2014). Nevertheless, the IUCN encourages rescue and rehabilitation programs to utilize the guidelines as a framework to assess rehabilitation programs even though they are not specific about what constitutes rescue and welfare rehabilitation (Baker 2002; Guy et al., 2014).

Wildlife rehabilitation is defined more specifically in relation to animal welfare. The American National Wildlife Rehabilitation Association (NWRA) defines rehabilitation as "the treatment and temporary care of injured, diseased and displaced indigenous wildlife, and the subsequent return of healthy viable animals to appropriate habitats in the wild" (Atkinson, 1997, p. 355), and welfare is an individual's "state as regards its attempt to cope with its environment" (Broom 1988, p. 6). Animal welfare is typically defined in terms of natural living (e.g., an animal should be able to perform its natural behavior and live a natural life), an animal's feelings (e.g., animals should be free from pain or stress), and an animal's biological function (e.g., animal should not experience reduced fitness, diseases, injury) (Fraser et al., 1997). As more non-human primates find themselves displaced by anthropogenic influences, the need to formulate guidelines specific to the reintroduction of rehabilitated animals becomes increasingly crucial. In addition, it is vital to disseminate any data related to welfare-based rehabilitation to address any issues that continue to plague these projects and to also ensure that they are improving the welfare of these individuals and promoting their long-term survival in the wild.

Proposed Criteria for Assessing the Suitability of *A. pigra* for Release

According to the IUCN guidelines for reintroduction, "released animals should exhibit behaviors essential for their survival and reproduction, and for compatibility with conspecifics." However, many ex-pets and rescued primates do not acquire the same skill level as their wild conspecifics (Cheyne, 2009). For this reason, it is crucial to evaluate individuals being re-introduced to assess their capacity to survive. Below, I have highlighted the important aspects of wild howler behavior that rehabilitated individuals must master prior to their release. These behaviors were used to create an ethogram of howler behavior.

The activity and dietary profiles of *A. pigra* in northern Belize are almost identical to that reported for other members of the genus in other areas (Silver et al., 1998). In northern Belize, *A. pigra* spends 61.9% of its time inactive, 24.4% feeding, 9.8% locomoting, 2.3% engaged in social activities (playing and grooming), and 1.5% vocalizing. A similar dietary profile has been observed in southern Belize with a general level of inactivity at 66.33% followed by 18.57% spent feeding, 7.49% locomoting, and 3.6% spent socializing (Pavelka & Knopff, 2004, p. 107).

In relation to social behavior, young howlers within a troop exhibit higher frequencies of play behavior. They will typically chase or wrestle each other, while giving low-pitched play grunts (Horwich & Lyon, 1990). Play behavior is important as it serves a key role in sensory, motor, social, and cognitive development (e.g., Fagen 1981, 1993; Spinka et al., 2001), which can be used later in life to evade predators, resolve conflicts with conspecifics, obtain a mate, or care for young (e.g., Fagen, 1981; Smith, 1982).

Aggression is a natural behavior in animals. In howlers, aggression can include vocalizations. Howlers are infamous for their loud vocalizations that can be heard throughout the day when they hear loud noises, before it rains, and when others are feeding. They are most common at dawn and dusk (Horwich & Lyon, 1990). Adult males exhibit aggressive behaviors when threatened. They often exhibit piloerection, which serves as a warning to its aggressor. They then raise and hunch their shoulders, while quickly leaning forward and grasping a tree branch (Horwich & Lyon, 1990). Male howlers also convey an angry message to other males using a gland on their throat region that leaves a scent after the male has rubbed his chest and throat on an object (Horwich & Lyon, 1990).

Grooming behavior, a widespread practice in many monkeys to maintain group peace, is rarely documented in howlers. However, when it is observed, it typically occurs between a male and female in a relaxed situation (Horwich & Lyon, 1990).

Reproductive success will be determined by the presence of mating behavior (Van Belle & Bicca Marques, 2015; Horwich, 1983a).

The inability to find food in natural environments poses a major problem for rehabilitation and release programs and is often associated with poor post-release survival rates (Britt et al. 1999; Cheyne 2009; Frantzen et al. 2001; Mills 1999). A survey response from rehabilitation centers associated with A. pigra, reported that they require assistance to recognize palatable foods (Guy et al., 2013). For this reason, it is important to evaluate the dietary profile of rehabilitated howlers prior to their release. The howler diet consists primarily of young leaves and fruit, with young leaf consumption averaging 37.2% and fruit averaging 40.8% of their monthly diet. However, mature leaves were consumed 7.9% of the time. On the other hand, flowers averaged 10.2% of their monthly feeding time, but flower consumption peaked during the dry season, making up 36.8% of their monthly feeding time (Silver et al., 1998).

Wild howler monkeys are an arboreal primate species that lives high in the canopy of tropical rainforests. They generally avoid coming to the ground, but will occasionally descend to the ground to cross gaps between trees in highly fragmented forests (Pozo-Montuy & Serio-Silva, 2008). Nonetheless, arboreal species usually avoid being on the ground, as it poses an increased risk of predation. When released, it is important that howlers remain in the canopy and are not seen travelling near the ground.

All howlers at the primate rehabilitation center have interacted with humans in some form during their time in captivity. As a result, many have become dependent on humans. Due to their dependence on humans during captivity, many of these primates demonstrate a low chance of surviving post-reintroduction. For this reason, it is important to provide *A. pigra* with semi-wild enclosures with limited human contact to ensure their independence from humans and enable their survival in the wild (Baker, 2002).

Howlers are highly arboreal, containing prehensile tails that serve as a fifth limb, to grasp branches and anchor the body during feeding time and locomotion (Marsh et al., 2008; Di Fiore et al., 2011).

Group cohesion is important for survival, territory defense, and raising successful offspring. Howlers feed, sleep, and travel together (Horwich & Lyon, 1990). For this reason, group cohesion is taken into consideration in this study and measured through proximity to conspecifics.

CHAPTER III

METHODS

This Study

Wildtracks' overall goal is to increase the viability of howler populations in Belize by working with the Forest Department to end the illegal primate trade (a critical threat to primates throughout much of Central America) and by helping improve conservation planning to decrease habitat loss and fragmentation, which is a primary threat to the species. The aim of this study was to assess confiscated and rescued *A. pigra* as they were rehabilitated for reintroduction to the wild. The specific objectives of this study were the following: (1) identify what protocols and procedures are in place at Wildtracks for pre-release rehabilitation and post-release monitoring; (2) observe and record pre-and post-release behaviors to document the behavioral repertoires of individuals in each stage of the rehabilitation process; (3) compare pre- and post-release behavior to that of wild conspecifics as reported in the primary literature; (4) formulate a set of recommendations (based on IUCN guidelines: Baker, 2002) to further strengthen reintroduction protocols already in place at Wildtracks.

Based on the information stated in the primate literature related to rehabilitation practices, for my second and third objectives, I predicted the following: that as time in rehabilitation increased (1) rehabilitants would demonstrate a decrease in observed stereotypic behaviors; (2) an increase in naturalistic species-typical behaviors (e.g., grooming, copulation, play); (3) an increase in group cohesion, as measured through proximity; and (4) a reduction in behaviors associated with human dependency (e.g., approaching humans).

Research Site

This research was performed in two different locations in northeast Belize, Central America. Pre-release observations of *A. pigra* were conducted at Wildtrack's Primate Rehabilitation Center located in the northeast corner of Belize approximately two miles southeast of Sarteneja on the shore of Corozal Bay. Post-release observations were conducted at the Fireburn Reserve. The reserve is an 1818-acred area that is home to a Creole community and their surrounding farmland. It is also home to a variety of flora and fauna including 177 plant species, 36 species of mammals, 208 species of birds, and 65 species of reptiles and amphibians. The wildlife in this area has protective status under the Shipstern Nature Reserve owned by the International Tropical Conservation Foundation. Together, Wildtracks and the Fireburn community manage the reserve located on the Eastern shore of Shipstern Lagoon in the Corozal District of northeastern Belize (18° 12' 21.5994" N, 88° 11' 16.8" W) (Figure 1) (Wildtracks, 2017). Historically, the Fireburn community has occupied and managed this area for over 125 years (Maskell et al., 2009). In the past, the reserve has been utilized by the surrounding community for agriculture. In addition, the area has been logged for "Mahogany (*Swietenia macrophylla*), Ciricote (*Cordia dodecandra*) and Chicle (*Manilkara sapote*)," resulting in the removal of older trees in the area. Consequently, the forest in the area consists of younger trees less than 65 years old (Maskell et al., 2009).

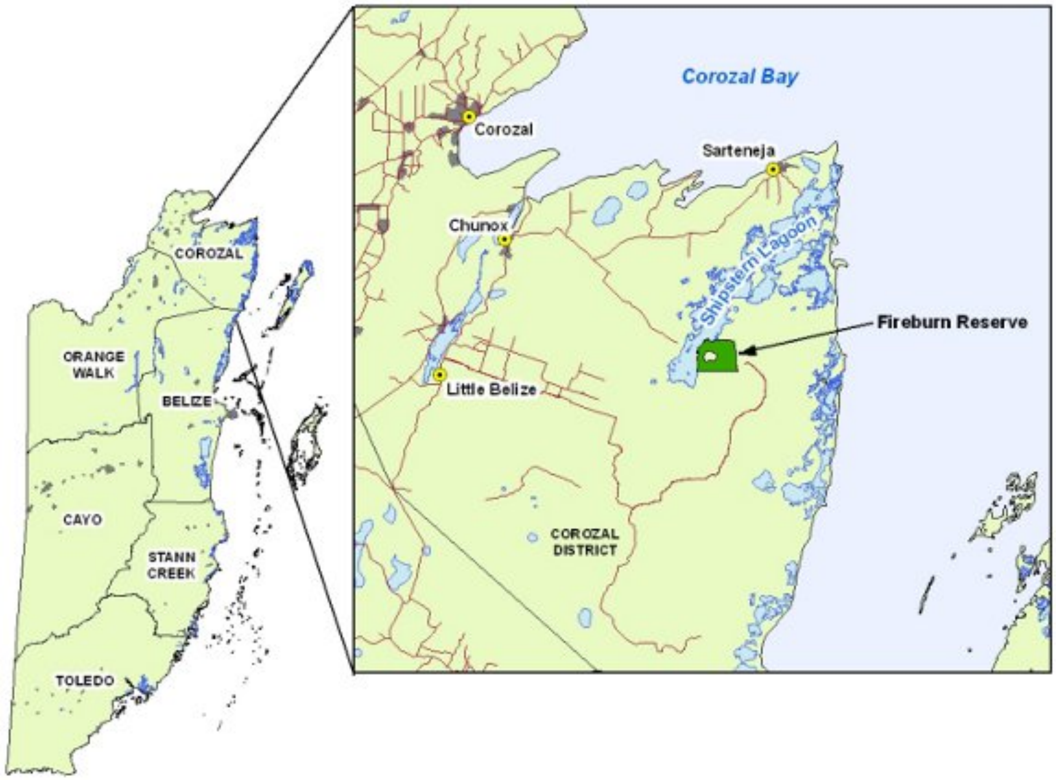

Figure 1. Map of Wildtracks' protected areas in Belize and the location of the release sites (Wildtracks, 2015).

Identification of Protocols and Procedures

To identify all protocols and procedures in place at Wildtracks, I created a checklist based on the guidelines listed by the IUCN (Baker, 2002; Guy et al., 2014) (Table 2), as these guidelines are considered "best practice" and deemed important to optimize successful rehabilitation and reintroduction. I then compared the two to determine how much of Wildtracks' approach was adopted from the IUCN guidelines (because these guidelines are meant to maximize positive outcomes) and how much of the approach is taxon-specific for that region. The goal is to make this information accessible to other rehabilitation and re-introduction projects to ensure that they achieve their conservation goals with minimal side effects to the individuals being re-introduced.

Table 2

Summary of Protocols in Place at Wildtracks in Comparison to IUCN Guidelines for Nonhuman Primate Re-introductions.

Stages	Wildtracks' Procedures
Arrival	✓ Quarantine (>31 days recommended) ❖ Thorough Medical Examination Vaccinations (as recommended) (Missing)
Assessment	✓ Source (e.g., ex-pet, wild, orphan) ✓ Evaluation of Socioecology and Behavior Genetic (geographic origin) (Missing)
Rehabilitation	❖ Natural Food ❖ Natural Enclosures ✓ Environmental Enrichment ✓ Resocialization with Conspecifics ✓ Limit Human Contact ✓ Group Development (size and composition similar to wild, behavior, group cohesion)
Pre-Release	✓ Behavior (e.g., foraging skills, human dependency, group stability) ❖ Health and Disease Screening ✓ Assess Suitability of Release Site (e.g., predators, habitat type, protective status, wild populations) ✓ Further Limit Human Contact Predator Awareness (Missing)
Release	✓ Transport Plan ✓ Soft Release (acclimatization to new environment, supplemental food and water).
Post-Release	✓ Long Term Monitoring Long (adaptation to environment, behavior, ecology, demographic, health, impact on habitat, mortality, reproductive behavior, and social changes)

Source. Baker (2002); Guy et al., (2014), p. 163-164.
Notes' Check marks indicate that procedures are in place, asterisks indicate that some procedures are missing, and no mark indicates that no protocols are in place.

Protocols and Procedures in Place at Wildtracks for Pre-Release

Quarantine, Medical Examinations, and Vaccines

Quarantine procedures are in place at Wildtracks. Upon arrival, every howler is placed in a 2.4 x 2.4 x 2.7 m quarantine enclosure where they remain for a minimum of 30 days until they are medically cleared by a veterinarian (P. Walker, personal communication, November 15, 2016). However, during my two months at the rehabilitation center, veterinary visits were not observed.

During the quarantine period, the IUCN Guidelines for Primate Re-introductions (Baker, 2002) recommend conducting a thorough physical evaluation of an individual's dentition, eyes, weight, reproductive organs, parasite infestation, and previous injuries (Baker, 2002). The collection of blood and serum samples are also recommended to test for blood parasites, viruses, and infectious diseases. Fecal samples are collected by staff and are tested for intestinal parasites (e.g., giardia, roundworms, hookworms). Roundworms and hookworms are treated with Pyrantel (as recommended by the veterinarian). Giardia is also treated at the rehabilitation center, but documentation of treatment was not possible. Typically, these infections are treated with anti-biotics (Gardner & Hill, 2001). Serious cases of mange and giardia are assessed by a local veterinarian at the Belize Wildlife and Referral Clinic and treated with medication. Vaccines are not given to howlers, as they are not deemed necessary by the staff at Wildtracks. No other disease screening or treatment was observed at this time.

Assessment (Source, Genetics, Socio-ecology and Behavior)

Prior to arrival at the rehabilitation center, the staff at Wildtracks collects as much information (as possible) from the locals or authorities. Then, a behavioral and physical assessment of the howler's condition is performed to determine general health and origin. A comparison of captive and wild howler behavior is conducted in relation to the rehabilitant to determine whether the individual was a previously wild, orphaned, or a pet. When assessing a howler's condition, they look at their coat and weight for any obvious signs of ailments. A howler is considered to be in "good condition" if they demonstrate long, silky, dense black fur (Richardson, 2006; American Zoo, 2006) and are of the average weight for a male or female howler (Richardson, 2006). Poor condition is determined by poor fur quality and low weight. If a howler appears to be seriously injured or highly emaciated, then veterinary care is provided. Genetic information is not available for rehabilitants, and geographic origin is difficult to determine without genetic information. Wildtracks collects data on the ecology and behavior of this taxon, year-round through volunteer research and their relationship with the University of Leeds, which offers graduate students grants to conduct on-site research. Projects have focused on factors influencing the survival of releases (Tricone, 2018), effects of release site vegetation on *A. pigra's* foraging behavior (Hughes, 2012), foraging behavior (Denton, 2012), effects of resource distribution on territoriality (Linton, 2012), ranging behavior (Scott, 2017), and geographic distribution, biology, and status (Cavada, 2012).

Reduce Human Contact

The youngest monkeys (ranging between one week to ten months of age) are given 24-hour care from trained personnel. However, as they get older, their care is reduced to 8 hours. All other individuals in further stages of rehabilitation have human contact reduced to feeding times.

Rehabilitation (Natural Enclosures & Environmental Enrichment)

Young howlers in early stages of rehabilitation are provided with enrichment (ropes, swings, hammocks, kongs), lianas, and wooden structures to help them develop climbing skills. In the forest cage stage of rehabilitation, only natural wooden climbing structures, ropes, lianas, and hammocks are provided to promote more naturalistic movements across the enclosure. Pre-release enclosures are large patches of forest surrounded by electric fencing, containing trees similar to those found at their release site. However, within the enclosure they still contain a small cage where howlers can find fruit and water that is provided as a supplement by their caregiver. These enclosures do not contain enrichment and are arranged similar to their natural habitat with natural trees similar to the ones found at their release site. Pre-release enclosures are divided into three separate enclosures (pre-release one, two, and three). Pre-release one contains smaller trees than pre-release two. Pre-release two contains larger trees than pre-release one, but smaller than pre-release three. These enclosures are set up in this way to help newly introduced howlers adjust to new heights in the trees.

Rehabilitation (Natural Groupings)

Natural groupings exist for all individuals considered for release. For example, each group contained two or more individuals of the opposite sex or groups with all females.

Rehabilitation (Natural Food)

Howlers are not provided with a fully natural diet. They are fed a combination of fruit (watermelon, papaya, banana, mango, apples) not found in their natural habitat and leaf browse that does grow naturally at their release site. For example, species such as bri-bri and ramon are commonly given to encourage foraging skills. Young howlers and low-weight individuals are given Ensure as a replacement for milk and source of protein to help them regain their strength and obtain a healthy weight.

Pre-release Assessment (Behavior and Foraging)

Staff routinely assesses group cohesion, locomotor, and foraging skills before moving individuals to new rehabilitation stages (P. Walker, personal communication, November 15, 2016). For example, young howlers that demonstrate group cohesion, confidence in their foraging abilities, and locomoter skills can be considered for the forest cage stage of rehabilitation. As a howler moves further into the rehabilitation process, naturalistic behavior should increase in frequency (see those listed in the proposed criteria for release above). Volunteer caregivers are also encouraged to report any abnormal behavior in rehabilitants. However, these reports are not always consistent and dismissed if an individual is not familiar with natural primate behavior.

Pre-release Assessment (Predators)

No predator response training is in place at this moment.

Pre-release Assessment (Health Check)

In this case, a dose of pyrantel and anti-parasite medication based on individual weight was given to rehabilitants before being moved to the transport crate. Fecal examinations are conducted routinely to determine parasitic infection, but from my observations, no pre-release health assessments exist, unless there are clear signs of physical ailments. No other health assessments were observed.

Pre-release Assessment (Further Reduce Human Contact)

During this time, the howlers are still provided with supplemental food, but human and howler interaction is limited to feeding.

Pre-release Assessment (Release site (Predators, Food & Water, Wild Conspecifics, Habitat Type, Protection Status))

The suitability of the Fireburn Reserve as a release site was last assessed in 2005. A previous study determined that the Fireburn Reserve could sustain growing numbers of re-introduced populations (in terms of food abundance and canopy structure) (Fanigliulo, 2005). However, no other assessments of the site have been conducted. The last population study was conducted by Fanny Tricone in 2015, but more recent population numbers are limited to tracker's knowledge and are difficult to determine (Tricone, 2018).

Release (Release Transport Plan)

Individuals were put into kennels and transported by boat to the reserve. After arrival, the kennels were zip-tied to large bamboo sticks and carried by the volunteers to their release site, which was approximately a mile and a half from the drop off location.

Release - Soft release (Acclimatize in Enclosure, Supplemental Food and Water)

Soft release enclosures are similar to the quarantine enclosures and measure 8'x8'x9'. Howlers remain in these enclosures for three days and continue to be provided with supplemental food and water. Volunteers and trackers are also encouraged to monitor their behavior and report any stress behaviors. However, from my observations, howlers that demonstrate stress behaviors may still be released.

Post-Release (Monitor)

Newly released individuals are monitored seven days a week for three months, and then are monitored every other week for up to one year. During this time, trackers observe general behavior, inter-group interactions, group stability, health, and reproductive behavior.

Study Group

Over the course of this study, behavioral observations were performed on 13 howlers housed at the rehabilitation center, including four who were released in June 2017. Post-release observations were conducted on these four howlers, totaling two male-female pairs, Balou-Kat and Darwin-Sansa (F) (Table 3). All howlers in this study were surrendered to Wildtracks or confiscated by the National Forest Department who brought them to the rehabilitation center. All howlers underwent an extensive rehabilitation process to ensure that they demonstrate a similar behavioral repertoire to their wild conspecifics, which is necessary for survival. All individuals were considered "captive raised," meaning they were wild born but spent time in captivity after their illegal capture (Cheyne, 2008). All methods were approved by Central Washington University's Institutional Animal Care and Use Committee and a protocol number (A011705) of approval was granted before the collection of data.

Table 3

Study Subjects' Name, Sex, and Months Spent in Rehabilitation, Age, Age Class, and Source.

Individual Name	**Group**	**Sex (M/F)**	**Months in Rehabilitation**	**Estimated Age**	**Age Class**	**Source**
Clifford	N	M	11	15.5	Juvenile	W
Roxy	N	F	13	17	Juvenile	W
Puck	N	M	4	9	Infant	XP
Jade	N	F	4	10.8	Infant	XP
Jo	F1	M	25	61	Adult	W
Brea	F1	F	14	50	Adult	XP
Molly	F2	F	11	23	Sub adult	W
Annie	F2	F	23	29	Sub adult	W
Anerie	F2	F	18	28	Sub adult	XP
Kat	PR	F	34	43	Sub adult	XP
Balou	PR	M	20	38	Sub adult	XP
Sansa	PR	F	33	51	Adult	XP
Darwin	PR	M	33	51	Adult	XP

Notes' W= Animals Born in the Wild, XP= Animals Kept as Pets

Data Collection

In this study, individuals at each stage of rehabilitation were identified by group, sex, age, and source (Table 3). Age classes were divided into four groups: infant, juvenile, sub-adult, or adult (based on Clarke, 1990). Individuals between 0-12 months were grouped into the infant category, rehabilitants between 12-36 months were classified as juveniles, individuals between 30-48 months were considered sub-adults, and adults were greater than 48 months. Age was calculated based on the estimated age at intake. Individuals were also identified based on their source of origin: captive, wild, pet, or rehabilitated.

Observational data for the nursery, forest cage one, and forest cage two stages of rehabilitation was collected three days/week for four weeks between July 01, 2017 and July 31, 2017, resulting in 12 days of observations, divided into five observation periods. Observational data for the post-release stage of rehabilitation was collected seven days/week for one week between June 12, 2017 and June 19, 2017, resulting in seven days of observations. Observations at the rehabilitation center began at 0700 and ended at 1700. Post-release observations began at 0500 and ended at 1900. Data was collected using two different observational methods: all occurrences and scan sampling. All occurrences sampling was used during all stages of the rehabilitation process to record vocalizations and stereotypic behaviors (repetitive behaviors without a clear function; Mason, 1991) to provide a greater understanding of the variables that affect the length of the rehabilitation process and survival rates in the wild (e.g., rocking, pacing, self-mutilation (excessive grooming), bite caging, etc.). Data collection for the quarantine and pre-release stages of rehabilitation was not possible, as there were no individuals in those two stages at the time of the study.

For the nursery unit, forest cages, and post-release stages, I performed 30-second scan sampling intervals for one hour, with a 30-minute rest and relocation between every hour (see Table 4 for information on enclosures sampled). With every scan, I recorded social interactions, aggressive, affiliative, and feeding behavior, as well as documented daily activities (e.g., time spent feeding, resting, locomoting, socializing, height in canopy, proximity, and interactions with humans) using an ethogram (Table 5). I adjusted this ethogram during the course of this study to include observed behaviors not listed.

Table 4

Enclosure Size Measured in Meters for Different Stages of Rehabilitation

Enclosure	Size in (m)	Group
Quarantine	2.4x2.4x2.7	N/A
Nursery Indoor Backroom	2.3x2.3x2.4	Cliff/Roxy/Puck/Jade
Nursery Indoor	1.2x1.2x2.1	Cliff/Roxy/Puck/Jade
Forest Cage Double Enclosure 1	6x3.7x3.3(2)	Jo/Brea
Forest Cage 2	4.8x4.8x2.7	Annie/Anerie/Molly

Table 5

Ethogram of Social Interactions between A. pigra

Non-Social Behaviors	**Description**
Vocalizations (VO)	Howls, loud, or quiet noises uttered from mouth
Abnormal (AB)	Pacing, rocking, cage-biting, over-grooming, self-mutilation
Resting (RE)	Lying on the ground, surface, or human in an inactive and relaxed state.
Locomoting (LO)	Move from one area to another (one tree to another or one side of the enclosure to another side.
Feeding-Drinking (FD)	Consuming leaf browse, insects, fruit, or water.
Observed on Ground (G)	Sitting, playing, or locomoting on the forest floor or at the bottom of an enclosure.
Proximity to Conspecific (P)	a. 0-2 m apart b. 2.1-4 m apart c. 4.1-6 m apart c. 6.1-8 m apart c. 8.1-10 m apart
Self-Object Play	Playing by themselves or with enrichment inside enclosures.
Social Behaviors	**Description**
Affiliative SO(AF)	Play, grooming, sexual behavior (copulating, sexual tonguing, exploratory behaviors: smelling the female's genitalia, urine, or vaginal discharge (Carpenter, 1934, Horwich, 1983)).
Agonistic SO(AG)	Aggressive threat, back arching, branch shaking, howling at another individual, piloerection, throat rub, or genital displays.
Human-Howler Behaviors	**Description**
Approaching Humans AH	Moving toward the direction of people, resting on human, playing with human or requesting play from them.
Approaching Humans AH(AG)	Aggressive threat, back arching, branch shaking, howling, piloerection, throat rub, or genital displays at the sight of human.

Troop Location

Eight howlers (one group of four and two pairs between the ages of 3 and 5 years) were released into the Fireburn Reserve in June 2017. However, post-release observations were only possible on one released male-female pair (Darwin and Sansa). A second pair was later introduced (Kat and Balou) when they came into contact with the first pair. Troops were located daily using auditory cues with the assistance of Wildtrack's staff. For example, on the first day, we began our follow at the release cages. We sought out the tallest trees in the area, and listened for any sign of howlers. Once we located our group, we followed them until they settled in their sleeping tree, which typically occurred around 1800. We then flagged the area and returned to the same site the following morning at 0500. Because many howler groups demonstrate site-faithfulness and have been observed occupying the same home range annually (Horwich & Lyon, 1990; Crocket, 1996; Pavelka et al., 2003; Di Fiore et al., 2011), this method proved to be the most effective for locating the group.

Identification of Troops and Individuals

Rehabilitated monkeys were identified using a method tested at Wildtracks by Anthony Denice (during his research as a CWU Primate Behavior graduate student), which has proven effective for identifying spider monkeys (Denice, 2017). This method uses photographs of the faces and genitals of each individual during their time at the rehabilitation center. Because each howler monkey (both males and females) has a unique pink shape on its posterior (Horwich, 1983b; Tricone, 2015), photographs of the face were taken from the front side of the howler, while the rear photographs were taken from an angle demonstrating the "continuity between the anus, perineum, and urogenital" (Tricone, 2015). Because a howler's face can change substantially during maturation, as well as the challenge of low visibility of their faces in the canopy, this method proved the most efficient for identifying howlers.

Analysis

I conducted a cross-population study of rehabilitant howler monkeys from various sources and in various stages of the rehabilitation process to determine behavioral repertoire differences. I utilized the R software program (R Core Team, 2017) for all statistical computations and graphics. For scan and all occurrence sample data, I calculated the frequency that each group (nursery, forest cage one, forest cage two, and post-release) was observed on the ground (G), interacting with humans (AH), feeding (FD), resting (RE), vocalizing (VO), socializing (affiliation, SO (AF); aggression, SO (AG)), locomoting (LO), and playing by themselves or with an object (S (OP)). After calculating frequencies, I calculated the proportions of behaviors and compared the proportions observed across the different stages of rehabilitation.

To determine the relationship between captive-type (e.g., amount of times observed on the ground (G) or interacting with humans (AH)) and wild-type behaviors (the proportions at which each individual was observed at different enclosure heights, foraging, locomoting, socializing or in close proximity to conspecifics) and age and time in rehabilitation, I conducted two correlation analyses. Pearson's parametric correlation was used when the data was normally distributed. Kendall's nonparametric correlation analysis was used when the data was not normally distributed and could not be transformed. Kendall's correlation analysis was used over Spearman's to reduce error associated with ties in the dataset. The null hypothesis is that there is no correlation between the variables ($r=0$) and the alternative indicates that there is a relationship between the variables ($r\neq0$).

The data met all assumptions of the Pearson's correlation parametric test (random sampling, linear relationship, interval data). To test for normality, I performed the Anderson-Darling test, which indicated that age, time spent in rehabilitation, and average proximity to conspecifics were normally distributed. Average height spent in the trees was not normally distributed, neither were the counts for AH, G, FD, or SO(AG), and transformation was not possible. Consequently, Kendall's non-parametric correlation analysis was used and all tests were analyzed using an $\alpha \leq 0.05$.

CHAPTER IV

RESULTS

Proportion of Total Behaviors Observed

All behaviors across all rehabilitant howler groups were examined, and howlers were most often resting (58.06% of the time) or feeding (17.11%) followed by locomoting (8.29%), socializing with conspecifics (6.61%) or humans (6.32%) and playing (2.65%). Rehabilitants were observed on the ground 0.95% of the time (Figure 2). Vocalizations occurred in 9.93% (N=1603) of observations. No stereotypic behavior was observed.

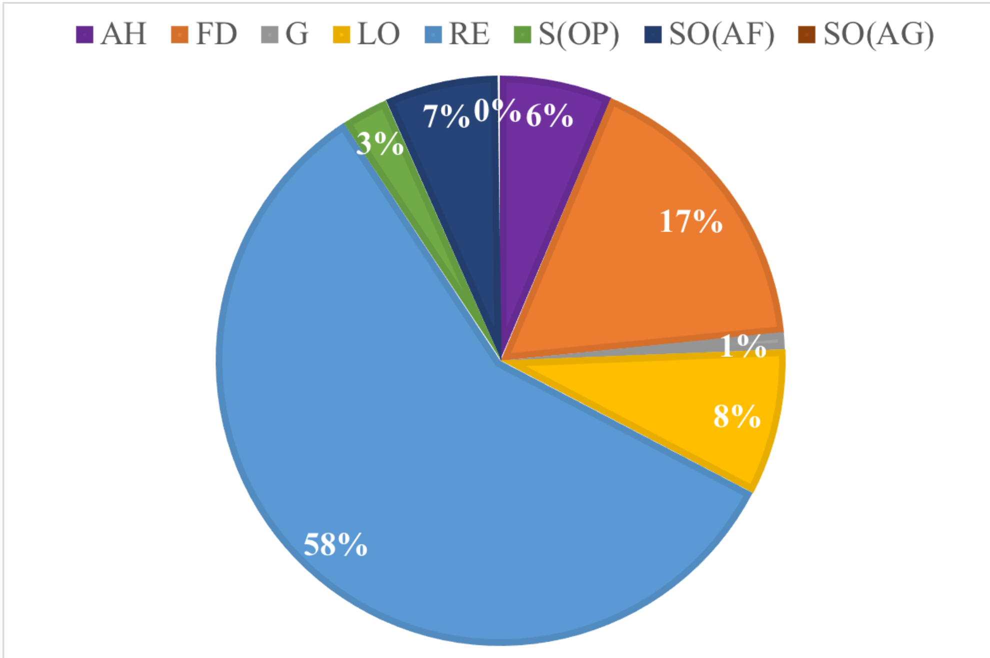

Figure 2. Proportions of total behaviors observed for all stages of rehabilitation.

Proportion of Behaviors Observed per Group

The nursery group (Roxy, Jade, Puck, Clifford) spent the majority of its time at rest (40.62%) followed by interacting with humans (14.49%), feeding (14.36%), socializing (12.03%), locomoting (9.47%), and self-object play (6.48%). Howlers in the nursery often vocalized (31.33% of the time) and spent the most time on the ground (2.54%) out of all rehabilitant groups (Figure 3).

The forest cage one group (Jo and Brea) spent 73.24% of its time resting, 14.80% feeding, 6.27% interacting with humans, 3.87% socializing, and 1.81% locomoting. This group was not observed on the ground and did not engage in play (Figure 3). Vocalizations were heard in 1.27% of observations.

Compared to forest cage one, the forest cage two group (Annie/Anerie/Molly) spent less time resting (45.50%) and interacting with humans (3.26%) and more time feeding (30.21%), locomoting (11.14%) and socializing (7.41%). These rehabilitants also engaged in self-object play (2.21%) and were observed on the ground (0.26%) (Figure 3). Vocalizations were heard in 1.38% of observations.

The post-release group (Darwin, Sansa, Kat, and Balou) spent 84.32% of their time resting, 7.32% feeding, 7.15% locomoting, 0.81% socializing, 0.33% on the ground, and 0.08% interacting with humans (Figure 3). Vocalizations were heard in 0.79% of observations.

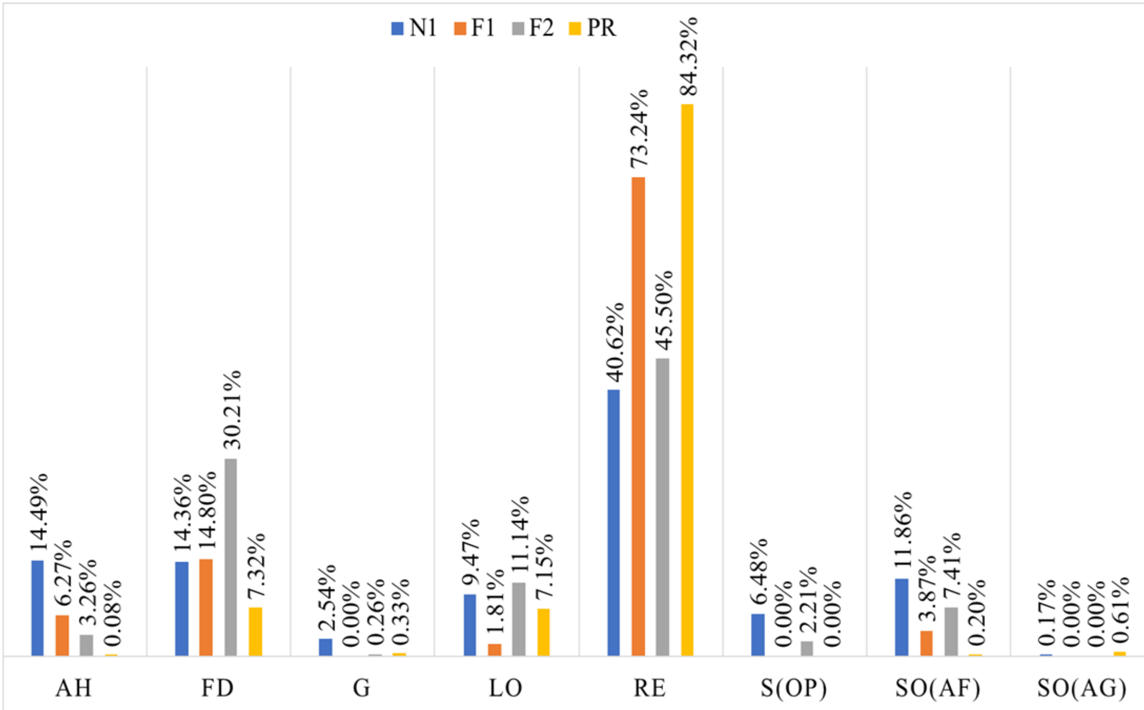

Figure 3. Proportions of behaviors observed for different stages of rehabilitation.

Time and Behavior

To compare the effect of time spent in rehabilitation (in months) on behavior, I ran a set of correlations. With an alpha level of .05, significant negative relationships were found between time spent in rehabilitation and time spent interacting with humans (*tau* = -0.66, $p < .002$) (Figure 4), time spent on the ground (*tau* = -0.57, $p < .009$) (Figure 5), and time spent engaging in affiliative social behavior ($r = -0.63$, $df = 11$, $p < .01$). A significant positive relationship was found between time spent in rehabilitation and average height observed in the trees (*tau* = .66, $p < .001$) (Figure 6).

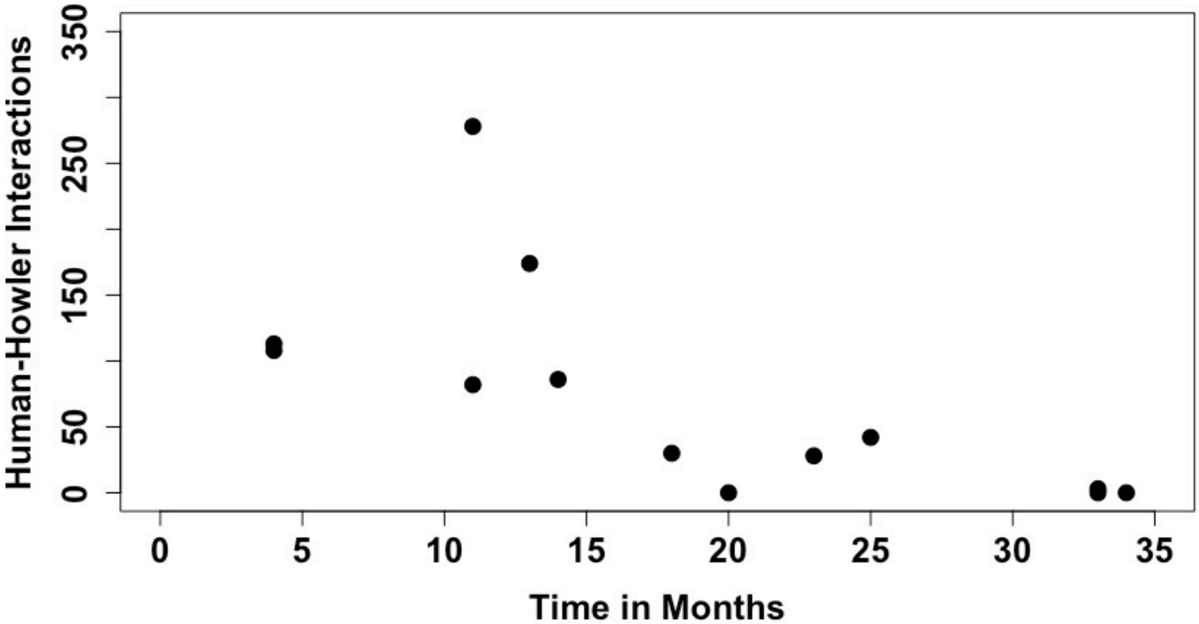

Figure 4. Negative relationship between the frequency of human-howler interactions and months in rehabilitation (Kendall's *tau* = -.66, *p* = .002).

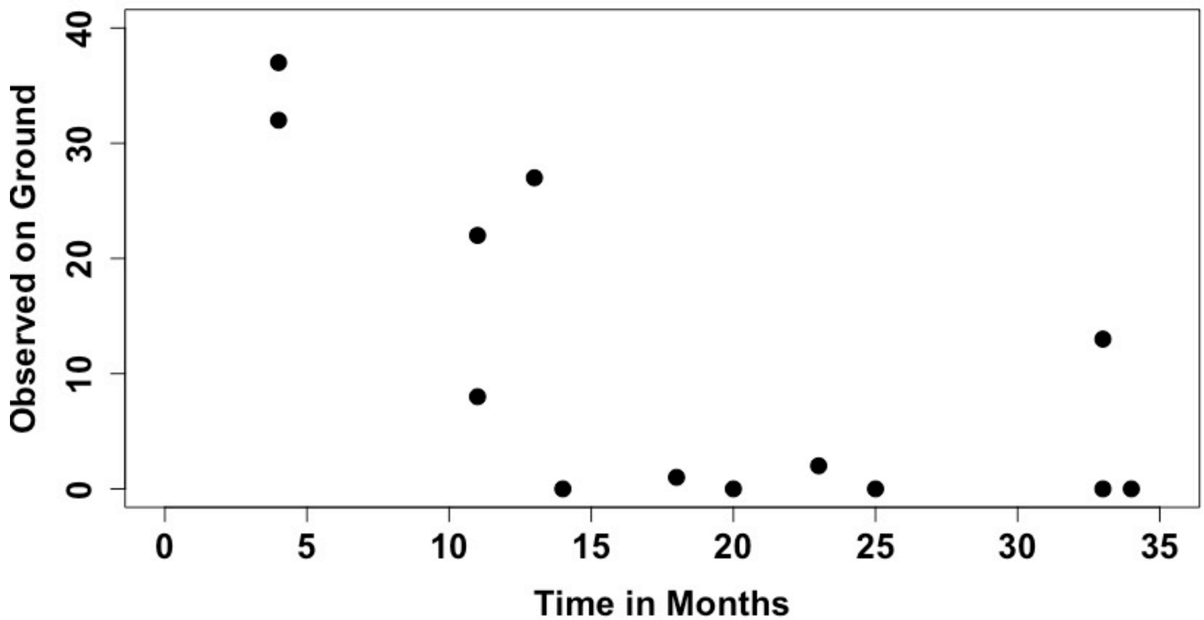

Figure 5. Negative relationship between the frequency of howlers observed on the ground and months in rehabilitation (Kendall's *tau* = -.57, $p < .009$).

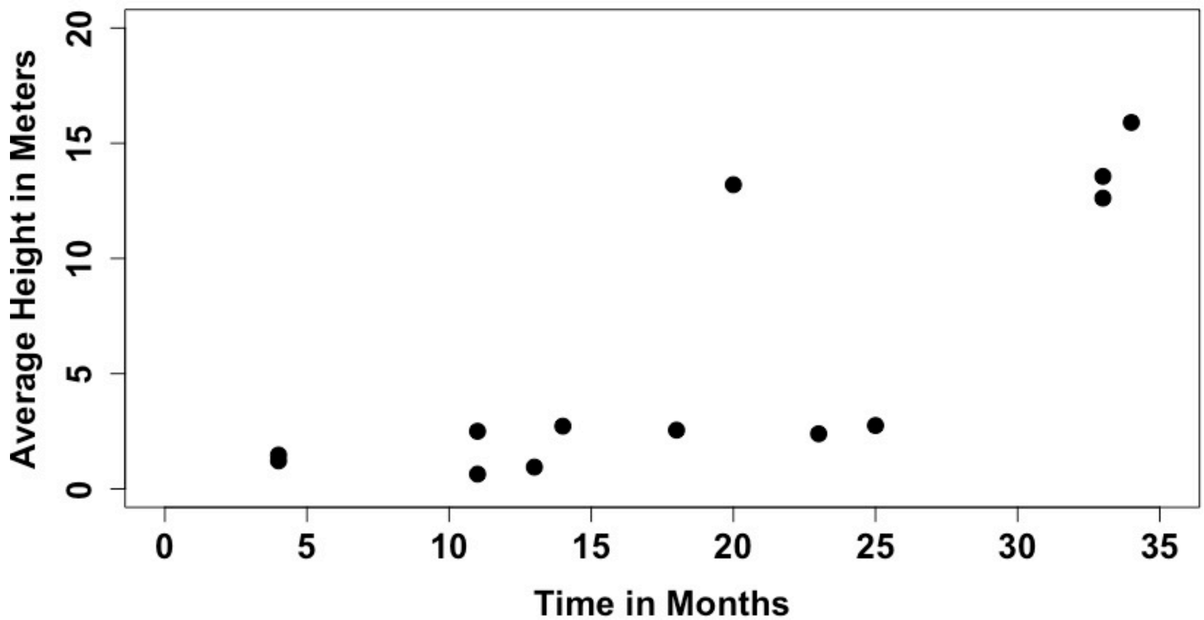

Figure 6. Positive relationship between average height observed in trees and months in rehabilitation (Kendall's *tau* = .61, $p < .003$).

Age and Behavior

Because the frequency data yielded differences in observed behaviors across the different rehabilitation stages with individuals of different ages, I ran a set of correlations to investigate the effects of age on behavior. With an alpha level of .05, significant negative relationships were found between a rehabilitant's age and time spent on the ground (*tau* = -.70, $p < .001$) (Figure 7), time spent interacting with humans (*tau* = -.50, $p < .01$) (Figure 8), time spent engaging in social affiliative behavior ($r = -.75$, $df = 11$, $p < .002$) and time spent playing alone or with an object (*tau* = -.78, $p < .001$). A significant positive relationship was found between a rehabilitant's age and average height observed in the trees (*tau* = .60, $p < .004$) (Figure 9).

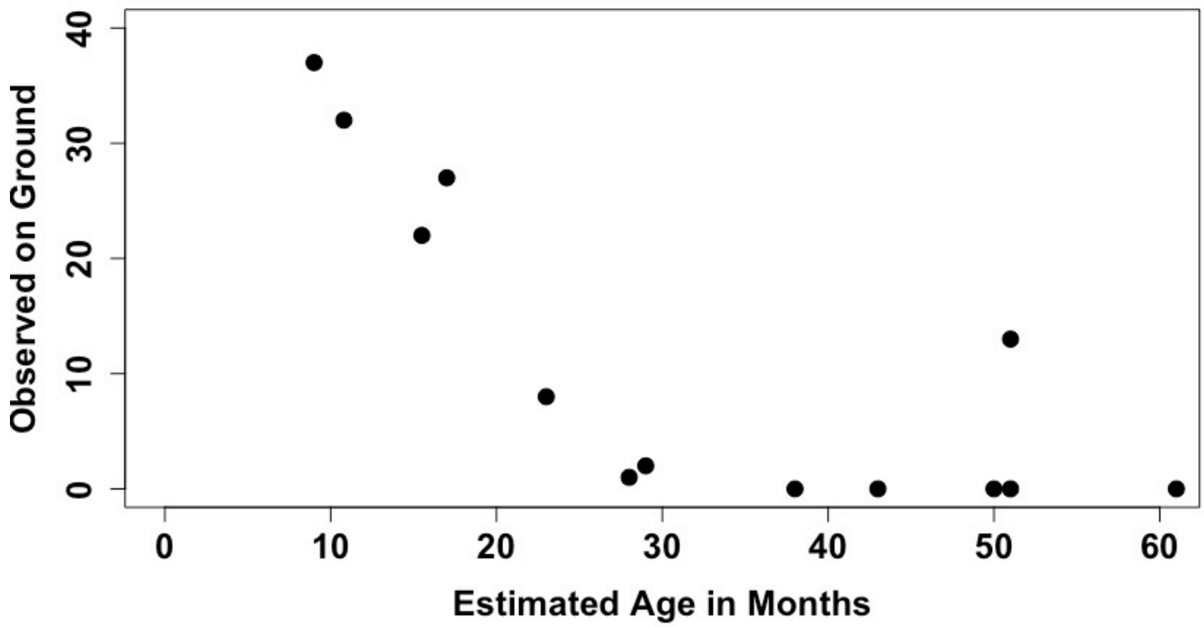

Figure 7. Negative relationship between frequency of howlers observed on the ground and estimated age in months (Kendall's *tau* = -.70, $p < .001$).

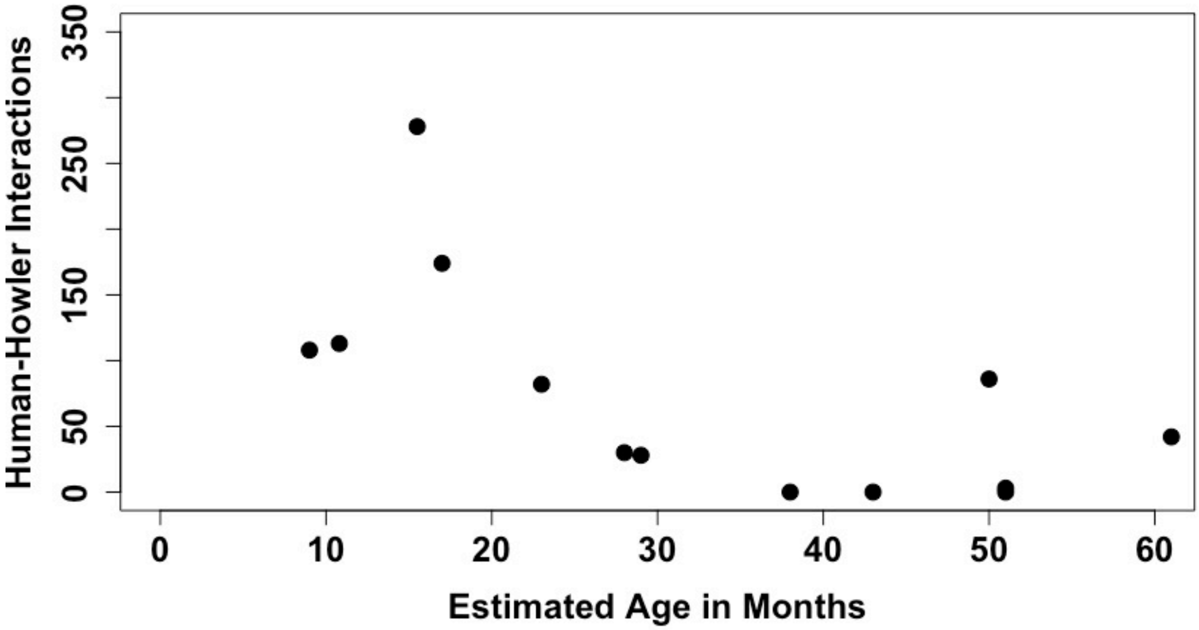

Figure 8. Negative relationship between frequency of human-howler interactions and estimated age in months (Kendall's *tau* = -.50, $p < .001$).

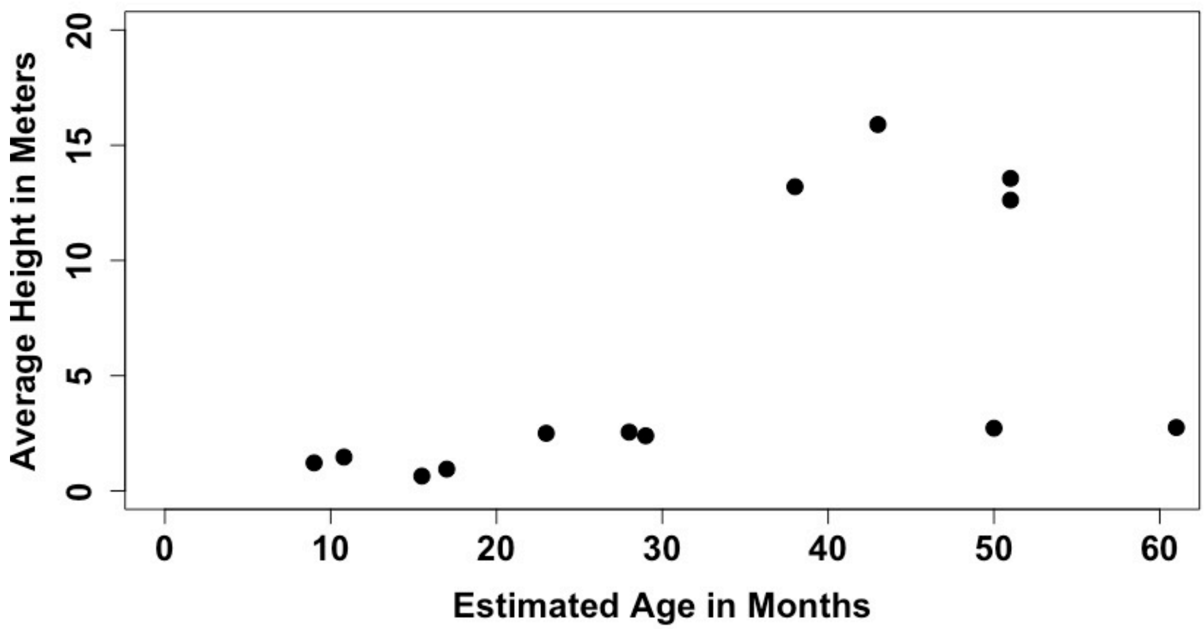

Figure 9. Positive relationship between average height observed in trees and estimated age in months (Kendall's *tau* = .55, p = .008).

Non-Significant Results

In this study, no significant differences were found between time spent in rehabilitation and time feeding (*tau* = -.24, p = .24), locomoting ($r = -.08$, *df* = 11, p = .77), engaging in social agonistic behavior (*tau* = .17, p = .44), or average proximity to conspecifics (*tau* = .17, p = .52) (Figure 10). Differences in age were also not significantly correlated with feeding (*tau* = -.19, p = .35), time locomoting (*tau* = -.36, p = .22), time resting (tau = .40, p = .05), time engaging in social agonistic behavior (*tau = .02*, p = .89), or average proximity to conspecifics (*tau* = .17, p = .52) (Figure 11).

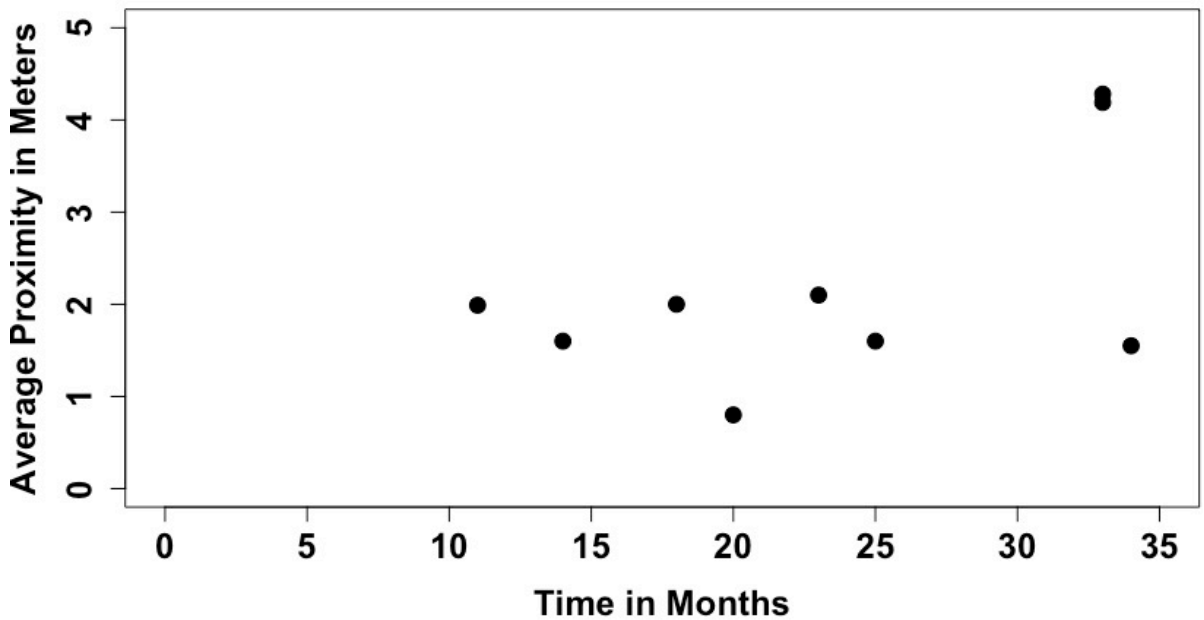

Figure 10. No significant correlation between average proximity in meters and months spent in rehabilitation (Kendall's *tau* = .17, *p* = .52).

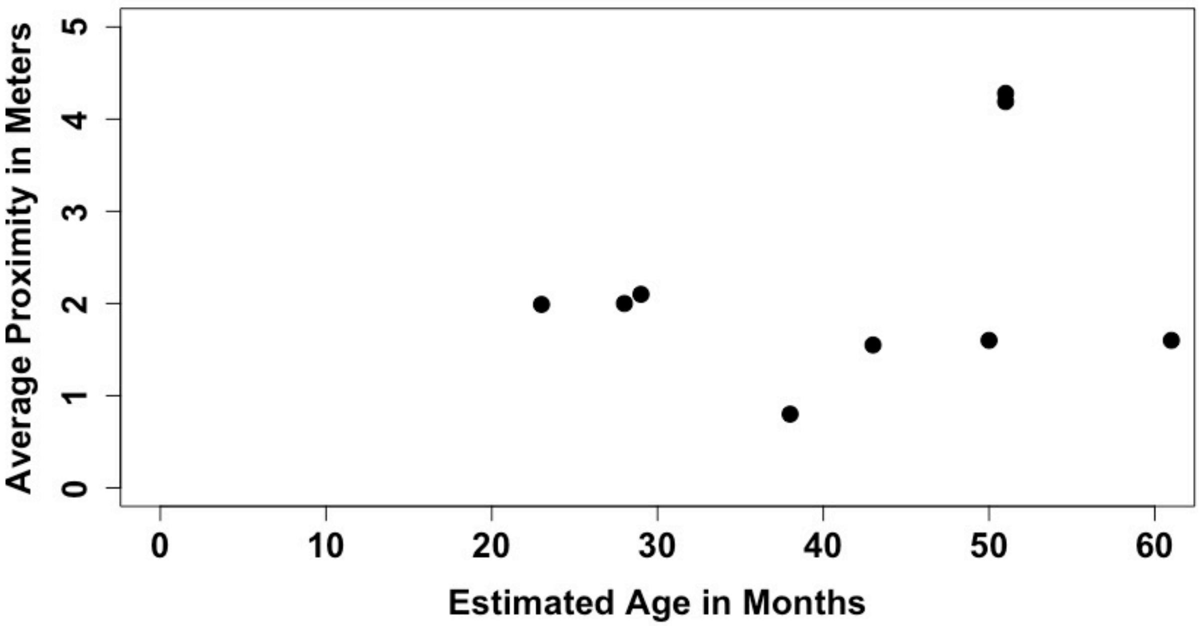

Figure 11. No significant correlation between average proximity in meters and estimated age in months (Kendall's *tau* = .17, *p* = .52).

CHAPTER V

DISCUSSION

The activity pattern of rehabilitant howlers followed the typical howler behavior pattern reported in the literature (Silver et al., 1998; Pavelka & Knopff, 2004; Prates & Marques, 2008) and was similar to that reported by Pavelka and Knopff (2004) for the population of *A. pigra* at the Monkey River site in southern Belize. Howlers at Monkey River typically spent an average of 66.33% of their day inactive followed by 18.57% feeding, 7.49% locomoting, and 3.6% socializing (Pavelka & Knopff, 2004, p. 107). This activity budget is expected, as howlers are known for spending more time inactive and less time socializing than many other primate species (Baldwin & Baldwin, 1978; Silver et al. 1998; Estrada et al., 1999; Pinto et al, 2003). A high level of inactivity is often correlated with their mostly folivorous diet and is thought to be in response to the consumption of low-quality leaves (Milton, 1980). Such leaves require an extended period of digestion and fermentation in the gut (Horwich & Lyon, 1990). Because much of a howler's time and energy is devoted to digesting plant material, they have little energy to devote to being social (Baldwin & Baldwin, 1978). However, more recent studies challenge this notion. Pavelka and Knopff (2004) argue that activity levels may be phylogenetically constrained because howlers maintain a sedentary lifestyle even during times of high fruit availability. It is also important to note that behavior varied between the different stages (see figures 2-5).

Predictions

The results of this study support the predictions that as time in rehabilitation increased, the behaviors of rehabilitant howlers would become more similar to the behaviors of their wild counterparts. Rehabilitants would decrease stereotypic behaviors, increase naturalistic behaviors (e.g., social interactions; group cohesion (measured through proximity); greater heights in trees), and decrease behaviors associated with human dependency (e.g., approaching humans). In addition, we expected older individuals with more time spent in rehabilitation to spend less time engaging in unnatural behaviors (e.g., interacting with humans; coming down to the ground; remaining low in the trees) than younger individuals in earlier stages of rehabilitation.

Human-Howler Interactions

Higher levels of human-howler interactions in group N1 were expected, primarily because in this rehabilitation stage, young howlers typically have a caregiver with them for an average of 8-10 hours per day. In the wild, non-human primates experience extensive parental care and long periods of infant and juvenile dependency (Yeager, 1997), resulting in strong social relationships between the mother and her infant. This is especially true in primate species that do not establish permanent sexual partnerships (Altmann, 1959). Often these relationships are mutual, affectionate, emotional, long-lasting and often characterized by a set of affiliative behaviors (allogrooming, provision of nourishment, warmth, protection, and maintaining close proximity) that allow for the transmission of information essential for the survival of the infant (Newberry & Swanson, 2008). Hence, a caregiver remains in close proximity to howlers in this stage to help them better adapt to separation from their mothers and reduce the negative impact associated with early (potentially traumatic) separation (e.g., cognitive impairment, depressed immunity, unresponsiveness, listlessness) (de Waal, 1996; Boccia et al.,1997). However, as howlers get older and move further along in the stages of rehabilitation, we can expect to see a reduction in human dependency. I did not expect to see individuals interacting with humans in F1 and F2 groups because Wildtracks reduces human contact to feeding times at these levels of rehabilitation. Indeed, human-howler interactions were limited to feeding times. This is a potential area for procedural improvement to further minimize human-howler interaction in this critical intermediate rehabilitation stage. With the PR group, interactions with humans were minimal and only observed after a fight between two adult male howlers. These human-howler interactions were mainly aggressive (e.g., howling at human observers).

On the Ground

None of the F1 group members were observed on the ground. However, howlers in the N1, F2, and PR groups were observed coming down to the ground, but this behavior was rare. Nonetheless, this behavior still comprised less than 3% of the N1 group's activity and can be explained by the caregiver's position within the enclosure. Caregivers typically sat on the ground in the far-right corner of the enclosure to avoid getting urine or feces on them. During infancy, howlers typically remain in close proximity to the mother, as it provides opportunities for the mother to transmit information to her young, such as, information about food sources and predators (Newberry & Swanson, 2008). Young howlers have also been observed playing with the mother's fur, ears, and limbs, as well as resting and crawling on the mother's body (Baldwin & Baldwin, 1978). This was also the case with N1 howlers. Many of the howlers were observed playing (e.g., biting caregiver, wrestling on them), resting on or next to the caregiver, and exploring the caregiver's body (e.g., playing with hair, reaching for eyes). Howlers in the N1 group were observed on the ground at a much higher frequency than all other groups. In F2, individuals came down to the ground during play and at feeding times when a caregiver was present. Individuals typically wrestled with each other and when wrestling became too aggressive, they would drop to the ground, travel to the other side of the enclosure and climb back up into the trees. One particular individual, Anerie, had the tendency to hang by her tail (1.5 m high), drop to the ground, sit there for a few seconds, and then climb back up to the top of the enclosure. In PR, only Darwin was observed on the ground. On one occasion, Darwin came down to the ground after noticing our presence. He came down to a height of approximately two m then proceeded to rest on the ground. The next day, Darwin was observed engaging in the same behavior after noticing our presence. This behavior was alarming, as wild howlers are recognized as being arboreal with locomotion adapted to an arboreal lifestyle (Carpenter, 1934). Although this behavior is rarely seen in the wild, Carpenter (1934) reports having personally seen a wild group travelling on the ground near the bank of a stream, as well as locals observing howlers coming down to the ground to travel from one group of trees to another. They generally avoid coming to the ground but will occasionally to cross gaps between trees in highly fragmented forests (Pozo-Montuy & Serio-Silva, 2008). Nonetheless, terrestrial locomotion is not the preferred mode of travel for the genus *Alouatta* (Carpenter, 1934) and was rarely observed in the latter stages of rehabilitation.

Height

Because howler monkeys are highly arboreal with locomotion adapted to an arboreal lifestyle (Carpenter, 1934), I expected height to increase as individuals matured and spent more time in rehabilitation. The results indicated a positive correlation between age, time in rehabilitation, and average height in trees. However, 9 out of 13 individuals sampled, (individuals 9-61 months old with 4-25 months in rehabilitation) were observed, on average, at heights <3m. The N1 group was observed on average at heights equal to 1.06m, while F1 was observed at heights equal to 2.7m, and F2 at heights equaling 2.4m. The PR group was the exception. Individuals in PR (38-41 months old with 20-34 months in rehabilitation) were observed, on average, at heights >10m. We did not predict rehabilitants would spend most of their time in the lower half of their enclosures, as this is not common in arboreal species. In the wild, howlers can typically be found feeding and travelling high in the upper part of the canopy and are seldom observed in the understory (Carpenter, 1934; Smith, 1977). One potential reason for a lower average height was that individuals in N1, F1, and F2 were confined to >3.3-m enclosures (Table 4), which limited their arboreal mobility. Hence, in relation to their enclosures, the F1 and F2 groups were observed spending most of their time in the upper part of their enclosures (see figures 12 and 13). At the Fireburn Reserve, the PR group was surrounded by trees >15 m, but these individuals were observed, on average, in trees measuring 13.8-m. These results are similar to those reported by Estrada et al. (2003) for the population of *A. pigra* at the Mayan sites of Calakmul, Yaxchilan, Mexico and Tikal, Guatemala. Howlers at the Fireburn Reserve were sighted, on average, at heights between 6-10 and 11-15 m.

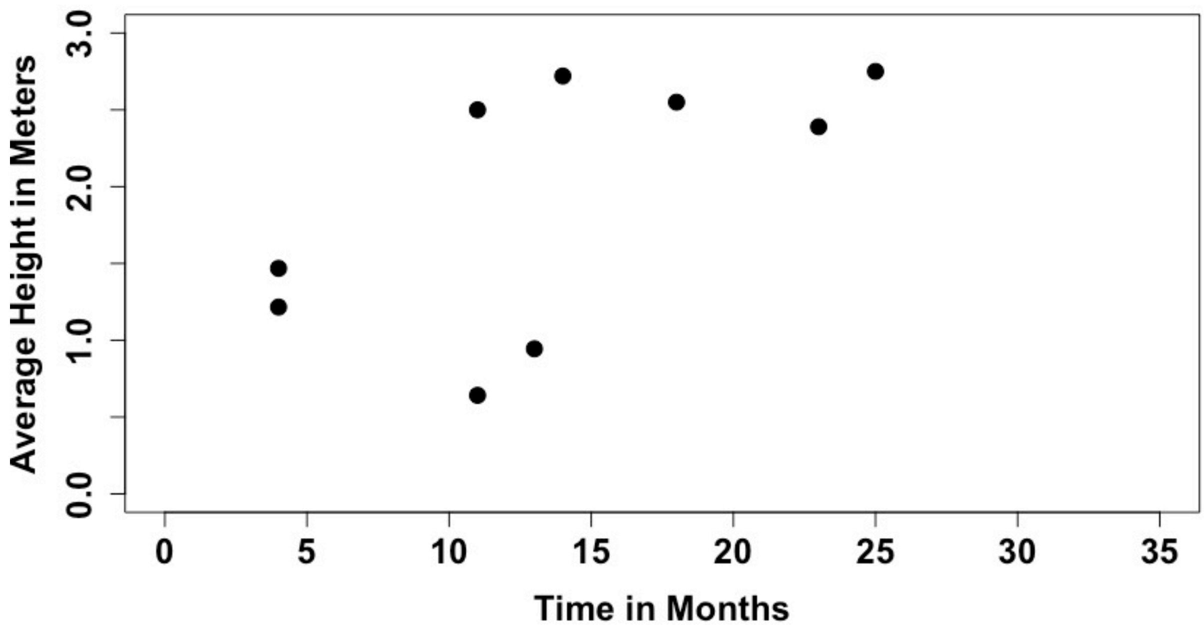

Figure 12. Positive relationship between average height observed in trees and months in rehabilitation with a y-axis of 3 meters (Kendall's *tau* = .61, *p* = .003).

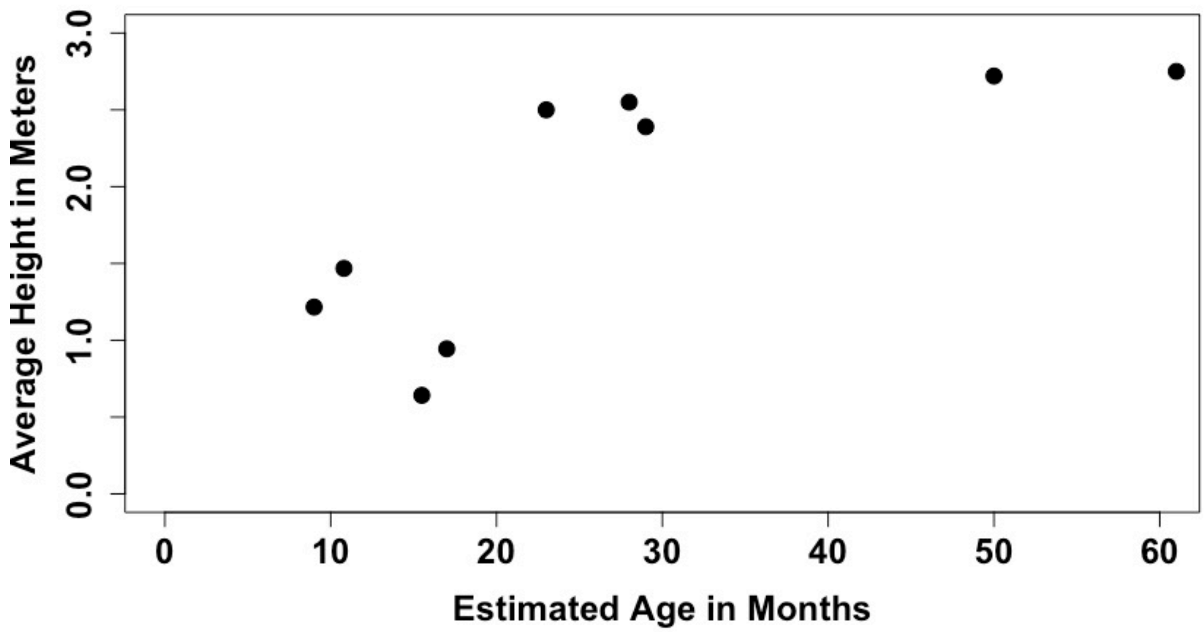

Figure 13. Positive relationship between average height observed in trees and estimated age in months with a y-axis of 3 meters (Kendall's *tau* = .55, *p* = .008).

Social Affiliative

Age and time in rehabilitation were negatively correlated to socially affiliative behavior, meaning that younger individuals with less experience in groups N1 and F2 socialized at a much higher frequency than groups F1 and PR. These results were unexpected; as socially affiliative behaviors were used in this study to measure group cohesion. Hence, we expected to see howlers in later stages of rehabilitation socializing at much higher frequencies than younger, inexperienced individuals. Although intragroup social interaction was observed in all stages of rehabilitation, the N1 and F2 groups had higher frequencies, predominantly play behavior. Play behavior is common amongst infants and juveniles, as it plays a critical role in the development and socialization of young animals (Baldwin & Baldwin, 1978; Fagan, 1981). It provides younger animals experiences that teach them social skills (e.g., sexual behavior, maternal behavior, controlled aggression) and expedite the process of integration into a social group (Baldwin & Baldwin, 1978). F1 was mainly observed engaging in mating behavior (sexual tonguing, copulating, genital licking) (Horwich & Lyon, 1990). PR was only observed engaging in agonistic social behavior, primarily after the PR group (Darwin and Sansa) came into close contact with another release group (Kat and Balou). At the sight of Balou, Darwin began to display a series of agonistic behaviors (e.g., piloerection, raised and hunched shoulders). Balou recognized the threat and attempted to run away, but Darwin approached piloerect and proceeded to attack him. The confrontation ended with Darwin knocking Balou out of the trees. Balou landed on a lower branch, but Darwin continued to chase him off. Balou finally dropped to the ground and ran off. This intergroup encounter is not unexpected, and although many howler species are not strictly territorial, they do not tolerate other groups in their immediate area

(Horwich & Lyon, 1990). Although affiliative behavior is rare in many howler species, grooming between Darwin and Sansa was observed (Di Fiore et al., 2011; Horwich & Lyon, 1990).

Non-Significant Results

In general, one would expect to see variation in behavior between the different stages of rehabilitation because of the separate requirements of the different sex and age classes (Marques & Marques, 1994). For example, infants and juveniles may require more energy from food than a larger inactive individual to aid in their development, while females may have different requisites to increase reproductive success (Marques & Marques, 1994; Pavelka & Knopff, 2004). On the other hand, adult males have been observed spending less time feeding and more time resting than females or young animals. This phenomenon has been observed across different primate taxa (*Alouatta villosa, Indri, Theropithecus gelada, Cercocebus albigena*) and has been primarily explained by the fact that males do not incur the costs of pregnancy and lactation (Clutton-Brock, 1977; Smith, 1977). The latter has been supported by Smith (1977) who observed females with dependent offspring spending more of their day feeding (18%) than males (14%) or females without dependent offspring. However, in sexually dimorphic species, males are also expected to consume more calories than females and younger individuals to sustain their larger bodies (Clutton-Brock, 1977).

Proximity

The results of this study revealed that there were no significant differences between age, time, and average proximity to conspecifics. Proximity data revealed that F1, F2, and PR spent most of their time between 0 to 2 m in proximity to conspecifics (see figures 10 and 11). On average, F1 was observed within 1.6 m of conspecifics, F2 was observed within 2.03 m, and PR was observed within 4.55 m. Although not statistically significant, remaining in close proximity to conspecifics is a good indicator of group cohesion. Group cohesion has been associated with positive rehabilitation (Schwartz et. al., 2016) and reintroduction outcomes (Shier, 2006; Cheyne, 2009) and may play a critical role in the survival of *A. pigra*.

Limitations

Although this study revealed positive results relative to pre- and post-release behavior, due to time constraints, it was not possible to determine the rehabilitation outcomes of pre-release training. In order to determine the success of a rehabilitation program, we would need to assess behavior from when an individual first enters the rehabilitation center up to their time of release, while considering the source of the individual. In addition, time affected our ability to conduct a full assessment of Wildtracks rehabilitation practices. Within my two-month period at the rehabilitation center, no individuals were observed in the pre-release stage of rehabilitation. In addition, no new individuals entered the rehabilitation center, therefore, a comparison between Wildtracks procedures in place for an individual's arrival and those outlined by the IUCN (clinical examination, disease screening) was not possible. However, this does not indicate that procedures are not in place. In fact, a recent study conducted at Wildtrack's rehabilitation center, reveals that monkeys undergo a thorough medical examination and are offered treatment, if required (Tricone, 2018). Certainly, like many other rehabilitation centers devoted to the conservation of wild animals, Wildtracks does everything possible with the resources available. Certainly, Wildtracks has offered many captive individuals a better quality of life and contributed to the preservation of wildlife biodiversity through the re-establishment of viable populations of threatened species.

Recommendations

As mentioned above, many rehabilitation protocols at Wildtracks were not observed; however, this does not imply that they are not in place. Nonetheless, based on my observations, I have formulated the following set of recommendations (based on IUCN guidelines: Baker 2002): 1) consider designing enclosures with greater heights; 2) encourage volunteers working with the nursery groups to move around the enclosure; 3) further reduce human contact in intermediate stages of rehabilitation; 4) re-assess the suitability of the release site; 5) conduct thorough medical examinations for all individuals entering the rehabilitation center; 6) reinforce disease screening and health assessments for staff and volunteers; and 7) implement a training program for new volunteers.

The IUCN recommends reintroduction managers offer rehabilitants natural training environments that provide individuals the opportunity to develop appropriate skills that are essential for their survival in the wild (Baker, 2002). In the wild, howlers are rarely observed at heights <3.5 m (Carpenter, 1934; Smith, 1977; Estrada et al., 2003). With this said, in this study, the upward mobility of rehabilitants was limited by enclosure size. For this reason, I have suggested developing enclosures with greater heights that can decrease the time it takes to adapt to the greater heights of trees at the release site. Following this further, in the wild, howlers do not typically interact with humans, they are rarely observed on the ground (Carpenter, 1934), and young howlers remain in close proximity to the mother (Baldwin & Baldwin, 1978; Newberry & Swanson, 2008). For this reason, I recommend volunteers that serve as surrogate mothers to young rehabilitants remain off of the ground and move around their enclosure. In addition, because all individuals sampled have been rescued from the illegal pet-trade, interactions with humans pose further complications for individuals after release (e.g. injury or death, as a result of hunting, individual's recapture for the pet-trade). For this reason, I am recommending reintroduction managers further reduce human contact in intermediate stages of rehabilitation. In this way, we can minimize the effects of captive behaviors and promote the development of more naturalistic wild howler behavior that result in positive release outcomes.

According to the IUCN, threats historically associated with the decline of a species must be identified and eliminated (Baker, 2002). In this case, it is critical to the survival of growing populations of A. pigra to ensure that the local community does not revert back to clearing land and practicing slash-and-burn agriculture. A possible solution to this problem would be to conduct an assessment of the local communities' attitude toward Wildtracks' rehabilitation project.

Moreover, it is recommended for rehabilitation centers to conduct a full clinical examination under a general anesthetic during the quarantine and pre-release stage. This would allow staff to collect blood samples and conduct more detailed assessments that can give them more in-depth information about the individual's health status prior to being integrated into a group. This step is also critical prior to release to prevent released individuals from spreading dangerous diseases to wild populations. In addition, it is also recommended that staff and volunteers working with wild animals, undergo regular training and health assessments to ensure the safety of both humans and animals. At Wildtracks, monkeys are constantly in contact with humans and may be exposed to a variety of pathogens. Hence, it is important to take precautions to reduce the exchange of anthropozoonotic and zoonotic diseases.

CHAPTER VI

CONCLUSION

Despite limitations, the results of this study support the predictions that as time in rehabilitation increased, the behaviors of rehabilitant howlers would become more similar to the behaviors of their wild counterparts. Overall proportions of observed behaviors revealed that the activity patterns of *A. pigra* at Wildtrack's follows the typical howler behavior pattern reported in the literature for wild populations (Silver et al., 1998; Pavelka & Knopff, 2004; Prates & Marques, 2008). In addition, I predicted that rehabilitants would decrease stereotypic behaviors (stereotypic behavior was not observed for individuals considered for release), increase naturalistic behaviors (e.g., social interactions; group cohesion (measured through proximity); greater heights in trees) and decrease behaviors associated with human dependency (e.g., approaching humans). The results of this study revealed that as individuals matured and spent more time in rehabilitation, they spent less time interacting with humans, on the ground and spent more time at greater heights in the trees. Social interactions were used as a measurement of group cohesion, but was negatively correlated. However, social interactions may not be a good measure of group cohesion in howlers, as older individuals spend less time socializing and more time resting. Proximity was not correlated to time and age. All individuals remained within close proximity to conspecifics, hence, all demonstrated group cohesion. Despite rehabilitants demonstrating positive results relative to behavior, these results cannot be used as a measure of success, long-term behavioral assessments and post-release monitoring are necessary to determine an individual's successful adaptation to the wild, and therefore, the success of a rehabilitation program's rehabilitation techniques (Baker, 2002). With this said, as more non-human primates find themselves displaced by anthropogenic influences, there is an increasing need for long term studies on pre-release training methods and rehabilitation outcomes. This way we can identify problems that continue to plague these projects and ensure that they are improving the welfare of these individuals and promoting their long-term survival in the wild.

Future Studies

From this study, I found that it is impossible to conduct a full assessment of welfare-based reintroduction projects to investigate what protocols yield positive behavioral results associated with successful post-release outcomes without considering the many ecological, cultural, and economic factors that may have implications for the welfare and conservation of endangered species. It is simple to ascertain the failure of a reintroduction project, but determining its success can be particularly challenging. Conducting a thorough assessment of a reintroduction project requires long-term qual- and quantitative data. However, this data is typically not available for multiple reasons. One of these reasons is that there are no generally agreeable criteria to determine success (Fischer & Lindenmayer, 2000). Success is often correlated to the introduction of viable, self-sustaining populations that do not require long-term monitoring (Fischer & Lindenmayer, 2000; IUCN/SSC, 1998). However, long-term survival is not the sole determinant of success, and researchers must also take into consideration the ecological, cultural, and economic benefits (or costs) that result from the preservation of this species or implementation of a reintroduction project. In addition, we must consider how the value of the species has contributed to conservation on a broader scale (e.g., conservation awareness, habitat preservation, the illegal pet trade). In the future, I would use a multi-disciplinary approach (e.g., interview local community members as well as governmental and resource management agencies) to assess Wildtracks' long-term contributions to conservation in Belize.

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