Spring 2020

Mommy Issues: Do Differential Rearing Histories Affect the Social Behavior of Captive Chacma Baboons (*Papio ursinus*)

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MOMMY ISSUES: DO DIFFERENTIAL REARING HISTORIES AFFECT THE SOCIAL BEHAVIOR OF CAPTIVE CHACMA BABOONS (*PAPIO URSINUS*)?

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A Thesis

Presented to

The Graduate Faculty

Central Washington University

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In Partial Fulfillment

of the Requirements for the Degree

Master of Science

Primate Behavior and Ecology

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by

Madeleine A. Spencer

June 2020

CENTRAL WASHINGTON UNIVERSITY

Graduate Studies

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ABSTRACT

MOMMY ISSUES: DO DIFFERENTIAL REARING HISTORIES AFFECT THE SOCIAL BEHAVIOR OF CAPTIVE CHACMA BABOONS (*PAPIO URSINUS*)?

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I observed the behavior of 17 chacma baboons (*Papio ursinus*) in order to understand the relationship between rearing history, dominance hierarchy, and social behavior. The Centre for Animal Rehabilitation and Education (C.A.R.E.) has utilized hand-rearing in the past and is currently using a surrogate-rearing method. Hand-rearing involves one or more primary caregivers attending to an infant for 6 – 12 months. Surrogate-rearing involves one individual being the primary surrogate for the first 3 months of the infant's life prior to bonding her or him to an adult female baboon before integrating both back into the surrogate's troop. Mother-reared individuals were also observed in this study. Mother-reared individuals are individuals who were born into the troop and raised by their mothers. I used a David's Score to assess rank and generalized linear mixed models to assess the effects that rearing history, rank, sex, age, and presence of kin in the troop, have on each individual's behaviors. I found no difference in rank between rearing history. Moreover, rearing history did not affect the rate at which individuals participated in species-typical behaviors. Individuals of

different rearing histories developed appropriate behaviors that mirror a wild troop based on their position in the dominance hierarchy, sex, and presence of kin in the troop. While my results suggest that both methods are successful for a rehabilitation setting, if resources are available, surrogate-rearing should be used as it replaces the lost mother figure and reduces human dependency earlier in life.

ACKNOWLEDGEMENTS

First and foremost, I thank my committee chair and advisor Dr. Sofi Blue for her continued help in developing this project and being there to teach and guide me each step of the way. I will always carry the knowledge she has shared with me and the lessons she has taught me in each of the following chapters of my life. I also want to thank Dr. Lori Sheeran and Dr. Jessica Mayhew for being a part of my committee, as well as their extremely valuable edits and mentorship through the process.

I thank Stephen Munro and Samantha Dewhirst for allowing this study to take place at C.A.R.E., as well as for their continuous help, support, and encouragement. Their commitment to continuing the mission of the late Rita Miljo inspires everyone who encounters it. Additionally, thank you to Becky Easter and Nadine Prole for assisting me with troop identification and Jo Marden and Sam Keegan for their continued hard work and educational outreach.

Furthermore, I thank Dr. Newton-Fischer for his assistance in interpreting the output of the Animal Behaviour Pro application which he developed. I thank Ruth Linsky for her help in selecting a statistical approach for my generalized linear mixed model analysis. I also want to thank the School of Graduate Studies and Research at Central Washington University for awarding me the Summer Fellowship. Additionally, thank you to Arlen and Debra of the Arlen and Debra Prentice Award, and the Barlow's for awarding me the Barlow Award. Without the help of each and every one of these individuals, this project would not have been possible. Thank you.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

My objective in this study was to investigate the relationship between differential rearing history and social behavior, including dominance rank, in a group of captive chacma baboons (*Papio ursinus*) at the Centre for Animal Rehabilitation and Education (C.A.R.E.). My aim was to fill a considerable gap in the literature by focusing on how differential rearing methods affect the behavior of individuals in rehabilitation settings. Publishing how differential rearing methods affect the social behavior and rank of chacma baboons in rehabilitation can be reviewed by other rehabilitation centers for their own use. Additionally, I wanted to understand how these methods may affect an individual's ability to develop species-typical behavior. Having a mother figure is an essential part of an infant's survival, learning, development, and socialization within the troop, therefore, assessing the relationship between rearing and behavior of orphaned individuals is imperative in understanding these methods.

Moreover, an individual's dominance rank can tell us vital information regarding health, reproduction, access to resources, and social support (Sapolsky, 2005), and can be an integral component in understanding an individual's health and welfare during their rehabilitation. By analyzing dominance rank in individuals raised in differential rearing methods, we can interpret a model of best-practices (i.e., hand-reared vs surrogate-reared) for rearing chacma baboons.

Confiscated or donated pets, habitat loss, and hunting (Ebua, Agwafo, Mbida, & Vaughn, 2014), as well as infants surrendered to rehabilitation centers (personal observation) are among a few reasons why wild populations of baboons are decreasing (Sithaldeen, 2019). C.A.R.E., a rehabilitation and reintroduction facility in Phalaborwa, South Africa, was first established in 1989 by Rita Miljo, who hand-reared a group of rehabilitated chacma baboons and reintroduced them to the wild (Munro & Dewhirst, 2020). Hand-rearing orphaned individuals involves a human surrogate being the main caregiver for that individual until they are integrated into a peer group between 6 and 12 months of age. When integrated into a peer group, they are slowly weaned off of human physical contact and dependence. In 2015, C.A.R.E implemented a rearing method called surrogate-rearing. Surrogate-rearing was implemented to reduce human contact as well as to adapt to limited space at the center and not to overburden the centers resources (*personal communication*, Munro, S.). Surrogate-reared individuals are with a human surrogate for the first 3 months of life and then are bonded to an adult female chacma baboon and eventually released back into the surrogate mother's troop. Additionally, while C.A.R.E. has a rigorous contraception program in place, accidental pregnancies do occur. These individuals who are born into the troop are raised by their mothers are mother-reared. Currently at C.A.R.E., the hand-reared and surrogate-reared individuals live together in multiple troops on site awaiting release. Differential rearing histories (i.e., hand-reared or surrogate-reared) have not been documented in detail in the literature in this setting, and I intend to fill this gap through

the investigation of the relationship between rearing history and an integral aspect of a baboon's life, dominance rank.

There is little published record that documents the rearing methods in this setting and more information is needed that would assist rehabilitation centers in providing the most optimal care for individuals. My intent in this study is to provide information that adds to existing guidelines on taking care of orphaned infant baboons. In sharing information on rehabilitation of captive species for reintroduction, facility staff will be able to understand which rearing method to use based on what they have available at their facility.

I assessed the relationship of differential rearing methods by observing the ranks of each individual through observations of outcomes of encounters (wins and losses) of dominant and subordinate behaviors. Additionally, I observed the affiliative and agonistic social behaviors between individuals. Individuals reared by their mother in the wild have had exposure to species-typical behavior and all the benefits a mother-infant bond provides (discussed in detail below), including initial acquisition of rank. Similarly, surrogate-reared individuals will have experienced a surrogate baboon mother and have been able to practice species-typical behavior and use this to build relationships with other troop members. Given this, I predict that (i) mother-reared individuals will occupy higher positions in the dominance hierarchy than surrogate-reared individuals and surrogate-reared individuals will occupy a higher position in the dominance hierarchy than hand-reared individuals. Next, I expect to find that (ii) surrogate-reared females

will rank adjacent to their adoptive mothers. Because males will usually rank adjacent to their mothers prior to maturation and outrank her once full grown, I predict that (iii) male surrogate-reared individuals will rank adjacent or above their surrogate mothers and other female's ranks. Surrogate-reared individuals will have been in the troop since they were infants and have been able to practice species-specific behavior with their surrogate mother which would potentially boost their ability to build strong relationships with troop members. For this reason, I predict that (iv) mother-reared individuals will participate in more affiliative interactions than surrogate-reared individuals and surrogate-reared individuals will participate in more affiliative interactions than hand-reared individuals, and (v) hand-reared individuals will participate in more agonistic interactions than surrogate-reared individuals and surrogate-reared individuals will participate in more agonistic interactions than mother-reared individuals. I conducted this research on a group of 17 chacma baboons at C.A.R.E. in South Africa with the help of Stephen Munro, Samantha Dewhirst. With their input and information from the literature, I observed the affiliative and agonistic interactions with conspecifics and assessed the rank of each individual in the focal group.

CHAPTER II

LITERATURE REVIEW

Welfare-based rehabilitation is defined as 'releasing captive primates including those orphaned and surplus to attempt to improve their welfare' (Baker, 2002, p. 33). This has become a tool used by rehabilitation centers such as the Centre for Animal Rehabilitation and Education (C.A.R.E.) in Phalaborwa, South Africa which rescues, rehabilitates, and releases chacma baboons (*Papio ursinus*) back into the wild. Rehabilitation center staff take on the responsibility of restoring the rescued individuals' species-specific behaviors, as well as their physical and psychological health in order for them to be reintroduced to and survive in the wild. Founded in 1989, C.A.R.E. specializes in the rehabilitation and release of chacma baboons (Munro & Dewhirst, 2020).

Natural History

The IUCN Red List categorizes chacma baboons as Least Concern, but the current population trend in the wild is decreasing (Sithaldeen, 2019). Some threats to this species include land fragmentation, problem animals being killed for behaviors such as crop-raiding, and being hunted for use in traditional medicine (Sithaldeen, 2019). Chacma baboons are classified in the genus *Papio*, which is comprised of six species. These are: hamadryas (*P. hamadryas*), guinea (*P. papio*), olive (*P. anubis*), yellow (*P. cynocephalus*), kinda (*P. kindae*), and chacma (*P.ursinus*) (Fischer et al., 2019). Chacma baboons live in female philopatric social groups consisting of infants, juveniles,

subadults, and adults, with multiple males, multiple females, and linear dominance hierarchies.

Baboons use behavioral thermoregulation by resting in the shade and drinking water during the hottest part of the day (King, 2016). They are very opportunistic in their behaviors, allowing them to eat a multitude of different foods and live in varying habitats and climates (Alberts & Gaillard, 2018). They are classified as omnivores and eat plants, grass, seeds, corms, bulbs, and roots (King, 2016). Baboons also have the ability to use human food sources. They can do considerable amounts of damage to crops and are considered pests for this opportunistic quality (Hill, 2000).

Chacma baboons are one of the largest species of monkey and are sexually dimorphic with males weighing an average 37 kg and females about half of that, weighing from 14.9 to 22.6 kg (Dechow, 1983). Adult coats are brown with yellow and black coloring spread throughout. Adult faces are dark grey featuring long prognathic muzzles and large canines. Infants are born with dark brown fur and pink faces that differentiate them from other troop members. Found in Southern African countries, chacma baboons inhabit grasslands, woodland savannas, sub-deserts, coastal regions, and mountainous areas, are largely terrestrial, and live in troops that average between 20 and 50 individuals (Sithaldeen, 2019). They have an average home range of about 15 km^2 (Stone, Laffan, Curnoe, Rushworth, & Herries, 2012).

Ontogeny

In contrast with other mammals, primates are immature for an extended period of time (Nash & Wheeler, 1982). Much like how we as humans would not have survived without the care and nurturance of our mothers and caregivers, baboons rely on this relationship as well, for survival and growth. Newborn baboons are altricial and can do little other than cling and suckle, needing continuous contact and care from their mothers to survive for the first 6 months of life (Alberts & Gaillard, 2018). This behavior of continuous contact is vital for alloprimates as it provides infants with nutrition, comfort, warmth, protection, and transportation (Nash & Wheeler, 1982). Baboon mothers start to wean their infants when they are between 10 and 15 months old, at which time mothers slowly reduce the amount of physical contact with their infants (King, 2016) and encourage independent development. If mother-infant separation in baboons occurs it not only stalls developing maternal skills for the mother, but also has negative consequences for the infant's development, survival, and normal species-typical behavior (Brent & Bode, 2006).

Baboon Society

Baboons live in social groups referred to as troops that are organized by a clear dominance hierarchy and matrilines. Infant baboons' rank in the dominance hierarchy is determined by their mothers rank as well as is correlated with the rates at which immatures receive maternal support during agonistic encounters (Cheney, 1977). Baboons build relationships through affiliative interactions such as playing and grooming

(Cheney & Seyfarth, 2007). Playing helps infant and juvenile baboons practice initiative and response behaviors they may encounter later in life such as fleeing, chasing, and biting (Owens, 1975). Play involving infant carrying, or 'maternal play', can teach females important maternal skills such as how to carry and protect an infant, and this can also decrease rejective or aggressive behavior towards infants as adults (Owens, 1975). Grooming is done to remove ectoparasites, but it also reinforces the bond between the two individuals who are then more inclined to support one another during agonistic interactions, to huddle with each other for warmth, and to share feeding sites (Cheney & Seyfarth, 2007).

In baboons, agonistic interactions are utilized not only in acquiring rank in the dominance hierarchy, but also in maintaining rank, challenging dominant male individuals, and gaining and maintaining access to vital resources. Female baboons maintain similar, adjacent ranks to their mothers throughout their lives (Cheney, 1977; Bergman, Beehner, Cheney, & Seyfarth, 2003). Baboon daughters are inversely ranked based on their ages, meaning that younger daughters will usually outrank older daughters and daughters usually rank below their mothers. In rhesus macaques (*Macaca mulatta*), this pattern is hypothesized to occur because the younger female has more reproductive value (Schulman & Chapais, 1980) and at a younger age, requires more maternal care than the older daughters (Alberts & Gaillard, 2018). Female baboons' linear dominance hierarchy can remain relatively stable for generations while male baboons' dominance hierarchy does not.

Prior to maturity, a male's rank is also based on his mother's (Hamilton & Bulger, 1990), but around the age of 5 years old, when he starts to outgrow all the adult females, a male's rank becomes based on his fighting ability (Cheney & Seyfarth, 2007). Young males engage in play fighting, during which dominant behaviors begin to emerge (Owens, 1975). When males reach sexual maturity (around the age of 8 years), many will emigrate from their natal troop and join other troops. Males use agonistic actions, threats, and vocalizations in order to find their new place in the dominance hierarchy and unlike females, male rank is challenged by others in the troop and changes frequently (Cheney & Seyfarth, 2007).

Social and Hormonal Correlates of Baboons

High rank provides access to resources including food and water, sleeping sites, and mates (Alberts & Gaillard, 2018). Life for baboons, both in captivity and in the wild, comes with inherent stressors for individuals and the troop as a whole. One way in which stress can be mitigated is through affiliative interactions (Crockford, Wittig, Whitten, Seyfarth, & Cheney, 2008). Affiliative relationships formed through social interactions are crucial for baboon's survival, as these relationships can help them to gain access to resources, support during agonistic interactions, and stress relief (Cheney, 1977; Cheney & Seyfarth, 2007). Individuals of higher-rank have more opportunity to gain access to resources, displace agonism onto lower-ranked individuals, and disrupt others' mating or grooming (Sapolsky, 1995). On the other hand, life for a low-ranked baboon of consists of a lack of opportunities to release frustration through displaced

agonism, little predictability, being disrupted during mating, and displaced more often (Sapolsky, 1995). Robert Sapolsky has devoted years of research to understanding the relationship between rank and stress in olive baboons (*Papio anubis*).

Glucocorticoids are made in one's body and occur as an adaptive stress response (Finsterwald & Alberini, 2014). Any threat to homeostasis will likely result in an increase in basal glucocorticoid hormones, such as cortisol, to survive the inherent stressor. However, chronic exposure to stress hormones can cause elevated basal cortisol concentrations during non-stressful situations. If cortisol is produced too often, this can lead to hypercortisolism which can produce negative physiological responses in the body. Sapolsky (1995) found that hypercortisolism that arises from intra-troop stress is more common in subordinate baboons. An individual who is consistently exposed to elevated stress hormones is likely experiencing disruptions in her or his growth, digestion, and reproduction (Sapolsky, 2005). However, there are several other behavioral traits in addition to being subordinate that can also predict hypercortisolism.

Sapolsky (1995), outlined certain social situations, and behavioral traits that highlight individuals who are more likely to have higher basal glucocorticoid concentrations. The first situation is whether or not the dominance hierarchy is stable, with stability being defined by the ratio of wins and losses between a pair. While dominant olive baboon males are often found to have lower glucocorticoid concentrations, during instability in the hierarchy, their basal level doubles in dominant individuals. Some behavioral traits that can indicate a higher glucocorticoid

concentration include those who don't understand the difference between a threat and neutral encounter with other baboons, as well as those with lack of predictability in their lives. Individuals who experience the least amount of affiliative and socially supportive interactions show heightened cortisol concentrations. Similarly, Abbott, Keverne, Bercovitch, Shively, Mendoza, Saltzman, Snowdon, Ziegler, Banjevic, Garland, & Sapolsky (2003), also found that across several primate species, individuals experienced higher basal cortisol concentrations when they experienced higher frequencies of stressors and had less opportunity to participate in social support both with kin and non-kin.

Rehabilitation and Rearing

Individuals who come into rehabilitation centers may already be at risk for a heightened stress response as all of them have experienced the trauma of losing their mothers and troops. Infants are usually the lone survivors of their troops when they are rescued or surrendered to rehabilitation centers (*personal observation*). Mothers and troops may have been the victims of road traffic accidents, poaching, poisoning, or pest-killings (*personal communication, Keegan, S.)*. Infants will have likely witnessed the death of their troop members when they are taken from their mothers' bodies and passed around from person-to-person, sometimes being sold into the pet-trade, before being rescued by the staff of a rehabilitation center.

Rehabilitation centers each have their own way of processing infants when they arrive. This usually involves an assessment of health, vaccinating, a period of quarantine

in which the individuals do not have access to other conspecifics (Guy, Curnoe, & Banks, 2014), and an individual being assigned as the main caregiver to the infant. From its inception until 2015, infants that were brought to the center spent 6 – 12 months with human contact, this process is call hand-rearing (HR). Having a human caregiver during this time ensured the individual received adequate care. Human caregivers engage in species-typical behaviors with infants to assist in development of social behavior as well as provide nutrition to ensure physical development. Infants also had regular contact with a peer group comprised of similar-aged conspecifics who became the infants' troop when they were moved to Phase II of rehabilitation, meaning they are integrated with a troop and no longer have physical contact with human caregivers. Infants had access to their main human caregiver and peer group members prior to moving into Phase II. At C.A.R.E., Phase II is located further from the volunteer side of the property, allowing for associations with human sounds, smells, and activity to be minimized. The idea behind this is so that once released, rehabilitated individuals are more likely to stay away from human activity than be inclined to roam towards it.

Wimberger, Downs, & Boyes (2010) contacted 63 rehabilitation centers across South Africa, of which, 20 rehabilitated primates including galagos (*Galago* spp.), vervets (*Chlorocebus* spp.), and baboons (*Papio* spp.). With considerably more primate rehabilitation centers opening up across South Africa, creating conspecific groups of similar-aged individuals has become less feasible, as less infants are coming into the center. This is also partially because C.A.R.E. diverts some infants who are surrendered

to them to different rehabilitation centers in order to ensure that the center does not become overburdened. For this reason, as well as wanting to decrease the amount of time infants spend with humans, C.A.R.E. has implemented a process called bonding. The Pan African Sanctuary Alliance (PASA) suggests that all infants need their mother or a surrogate for normal psychological and social development, and as soon as the individual is deemed to have no communicable diseases, should be integrated with conspecifics (PASA, 2009). The PASA Veterinary Manual also suggests is using adult females to help with integrating infants with conspecifics. C.A.R.E. has put this consideration into place.

Currently, C.A.R.E.'s method of rearing infants involves bonding infants to surrogate female baboons, this method is as follows. When an infant arrives at the center, they are given initial health checks and vaccinations and kept in Phase I at the center for at least 3 months. In Phase I, rescued infants only have access to other rescued infants (if there are any in that phase at the time) and their human caregivers. During that time, they have one main human surrogate with whom they spend the majority of their time and who is responsible for their care and well-being. Once the infant can climb, is behaviorally adjusted, and roughly 3 months old, they will begin to be bonded to an adult female baboon. The adult female is removed from her troop, tested to ensure she is not carrying any communicable diseases, and placed into a bonding enclosure. There is a human side and a baboon side in the bonding enclosure, with a door connecting the two that is only large enough for an infant to fit through.

Over the course of 21 days (sometimes less), the infant and adult female interact through the grate that separates the two sides. The infant can come and go from the baboon side as he or she pleases, building their confidence to interact with the adult female day by day. Once considerable progress has been made, for example, that the infant allows the adult female to groom and carry him or her, the door between the human and baboon side is closed with the infant on the baboon side. The two spend an additional 7-day period in the bonding enclosure together and are monitored by caregivers to ensure that a stable relationship has formed. After this, the two are moved to an enclosure adjoining the troop that the adult female originated from and they spend the next 7 days in this enclosure to allow the troop members to associate with the new infant with the adult female. Lastly, the two are released into the main troop area to socialize with group members. This bonding rearing method is called surrogate-rearing (SR). Using this method, the adult female baboon takes the place of the mother the infant lost, and the infant spends minimal amount of time in direct contact with humans. According to the Pan African Sanctuary Alliance's Veterinary Health Manual, hand-rearing should mirror a mother's bond, protection, and contact and integration with conspecifics should occur as soon as possible (PASA, 2009). Lastly, mother-reared (MR) individuals are the third rearing category in my study. MR individuals were born into the troop and raised by their biological mothers. These pregnancies are rare, as C.A.R.E. has a rigorous contraception program in place.

Predictions

Because surrogate-reared individuals are bonded to adult female baboons who serve as their alloparents, I predict that (i) mother-reared individuals will occupy higher positions in the dominance hierarchy than surrogate-reared individuals and surrogate-reared individuals will occupy a higher ranked position in the dominance hierarchy than hand-reared individuals. Because females normally acquire their mother's rank, I predict that (ii) surrogate-reared females will rank adjacent to their adoptive mothers. Since males will usually rank adjacent to their mothers prior to maturation and outrank her once full grown, I predict that (iii) male surrogate-reared individuals will rank adjacent to or above their surrogate mothers and above other females ranks. Surrogate-reared individuals will have been in the troop since they were infants and been able to practice species-specific behaviors with their surrogate mothers which would potentially boost infants' abilities to build strong relationships with troop members. For this reason, I predict that (iv) mother-reared individuals will participate in more affiliative interactions than surrogate-reared individuals do and surrogate-reared individuals will participate in more affiliative interactions than hand-reared individuals do, and (v) hand-reared individuals will participate in more agonistic interactions than surrogate-reared individuals do and surrogate-reared individuals will participate in more agonistic interactions than mother-reared individuals do.

CHAPTER III

METHODS

Study Site & Subjects

I conducted this study at the C.A.R.E. in Phalaborwa, South Africa. The center is located within the Grietjie Nature Reserve along the Olifants River in the Limpopo Provence. C.A.R.E. currently houses 450 baboons, most of whom are in the process of rehabilitation and release, while some have found their sanctuary on the grounds.

The study subjects consisted of individuals of different rearing histories including hand-reared (HR), surrogate-reared (SR), or mother-reared (MR). MR individuals were raised by their biological mothers after they were born into the troop (see Table 1 for male subjects IDs, ages, rearing histories, and rank, and Table 2 for females subjects IDs, ages, rearing histories, and rank). Study subjects include 17 individuals living in the Alice troop enclosure at C.A.R.E. Established in 2006, 11 of the troop members were hand-reared and ~ 13 years old when I collected data. Three individuals were surrogate-reared and bonded into the troop, and 3 individuals were mother-reared and born into the troop.

Table 1.

Male David's Scores, Rank Categories, Rearing Histories, and Age Classes

ID	Rank	Rank Category	David's Score	Rearing	Age Class
BB	1	High	15.45	HR	Adult
WO	2	High	12.15	HR	Adult
BU	3	High	11.10	HR	Adult
BA	4	High	10.84	HR	Adult
QU	5	High	9.04	SR	Subadult
FL	6	High	8.42	HR	Adult
HI	7	High	8.10	HR	Adult
AP	8	Low	7.17	SR	Subadult

Table 2.
Female David's Scores, Rank Categories, Rearing Histories, and Age Classes

ID	Rank	Rank Category	David's Score	Rearing	Age Class
VI	1	High	11.20	HR	Adult
RA	2	High	9.18	SR	Juvenile
VE	3	High	8.50	MR	Subadult
PP	4	Low	6.24	MR	Subadult
BG	5	Low	6.05	MR	Adult
AL	6	Low	5.33	HR	Adult
CA	7	Low	2.90	HR	Adult
PA	8	Low	2.53	HR	Adult
JA	9	Low	1.78	HR	Adult

In 2006, the troop consisted of 12 individuals hand-reared with human surrogate mothers until moving into Phase II of rehabilitation where they were integrated together to create this troop. Hand-reared individuals were raised by their human surrogate mothers for up to 12 months to ensure they received nutrition, vaccinations, and care. Caregivers slowly lessened their contact with these individuals to allow for them to begin building relationships with conspecifics while forming this troop.

In 2010, alpha female BE gave birth to female BG, adding another member to the troop. In 2012, BE died, and female AL was observed alloparenting BG (*personal*

communication, Munro, S.). In 2012, now alpha female VI gave birth to female VE, and then in 2013 female PA gave birth to female PP. In 2015 males AP and QU were bonded to surrogate mothers AL and VI, respectively, and in 2017, female RA was also bonded to surrogate mother VI.

Data Collection

I collected behavioral data using continuous focal animal sampling (Altmann, 1974). I observed individuals in 15 min intervals between 0800 – 1700 hr, four days a week, with a 5 min interval between samples to locate the next focal individual. Additionally, I took a 1 hr break at 1200 in order to avoid observation fatigue. I used a list randomizer from random.org make a randomized recording schedule of focal animals (Haahr, 1998). Once I finished collecting data for a particular randomized sequence, I used the random sequence generator to create subsequent sequences. This methodology was approved by Central Washington University's Institutional Animal Care and Use Committee (Protocol #2019-051) before data collection began.

During focal observations, I recorded the individual's ID, affiliative and agonistic behaviors, and the focal's designation as a "winner" or "loser" of dominance-related interactions (Huber, Ford, Bartlett, & Nathanlesz, 2015). My methods and determination of dominance-related behaviors are based off of a similar study that investigated dominance rank and affiliative and agonistic behavior between two groups of hamadryas baboons (*Papio hamadryas*) with differential early development (i.e., intrauterine growth restricted offspring versus control offspring; Huber et al., 2015).

Similar to Huber et al. (2015), my study focuses on rank related behaviors; therefore, I recorded behaviors based off of ethograms of affiliative, agonistic, and dominance-related behaviors already established for savannah baboons in the literature (Alberts & Altmann, 2011; Cheney & Seyfarth, 2007; Huber et al., 2015; Altmann, 1980; and behaviors from an ethogram provided by C.A.R.E.; see Table 3). I recorded behavioral data using an iPad with the Animal Behaviour Pro application (Newton-Fischer, 2012) programmed with my ethogram behaviors to categorize behavioral frequencies for each focal sample.

Table 3.

Ethogram of Behaviors used in Analysis

Category	Behavior	Description
Dominance	Displace	Individual walks towards another individual with a directed gaze and the individual being walked at moving away[4]
	Avoid	Individual moves away from another individual who is approaching
	Cower	Lateral flexion of the spine, often from a seated or crouching position; limbs usually held against the body but not always[1]
	Flee	Running away from an aggressor[3]
	Fear Grimace	Corners of mouth retracted and teeth (often clenched) exposed. Grimaces are sometimes given without being specifically directed[1]
	Keck	A vocalization “ackh ackh” short, sharp noise used for appeasement
	Scream	High pitched, shrill screech
	Tail Up	Tail held upright, or nearly so, or even 'pointed' forward over back. Note that tail movements occurring during "presents" should not be scored as agonistic behaviors unless they are unambiguously so (in this

Table 3 (Continued) Dominance		case there will usually be other submissive gestures also)[1]
	Wahoo	Two syllable call produced by males during aggressive displays[2]
Affiliative	Play	Wrestle, mouthed biting (not prolonged and not clamping teeth down), grabbing/hitting (without causing screaming)
	Lipsmack	Rapid, repetitive opening and closing of lips; may also include rapid repetitive opening and closing of lips on a flattened and projecting tongue[3]
	Grunt	A series of rapid monosyllabic sounds, usually of low volume[3]
	Touch	Putting a hand on another individual in a relaxed manner
	Embrace	Hugging another individual
	Carry	Carrying individual item with hands, arms, or on back
	Groom	Coordinated moving the fur of another individual using hands and/or mouth to pick at the skin/fur
	Grunt	A series of rapid monosyllabic sounds, usually of low volume[3]
	Huddle	Sitting with another one or more individuals with bodies touching

Table 3 (Continued)

Agonistic	Bite	Animal makes contact with any other part of another animal using its teeth. Terminates when contact is broken
	Chase	Animal pursues another retreating/fighting animal for a minimum of approximately 2m. Terminates when animal moves away from retreating animal or stops moving altogether
	Lunge	Animal moves suddenly towards another animal from a stationary starting position and stops just as suddenly
	Hit	Rapid, open-handed striking or attempted striking of another individual[1]
	Mob Noise	A short 'uhuh' vocalization directed at another to draw attention to situation and enlist others; usually coupled with flash/ground slap
	Scruff	Biting or grabbing the scruff of an individual
	Display	Hair raised/puffed up and running around the enclosure and/or on the spot; banging / jumping or bouncing onto mesh/platforms to add to sound / effect / often coupled with a Wahoo vocalization / shaking mesh / structures

Table 3 (Continued) Agonistic	Eye Flash	Display of unpigmented skin beneath eyebrows either by raising brow itself or tilting head dorsally; often accompanied by jutting forward of the head[1]
	Ground Slap	Slapping the ground with one or both hands to threaten an individual, often at the same time as raising eyebrows /head bob and mob-noise vocalization
	Head Bob	Moving head up and down rapidly; upper body often moves forward with the motion to threaten another individual
	Threat Grunt	Multisyllable, staccato, vocalization[2]
	Threat Yawn	Directed gape or yawn-like moving, usually exposing canines[1]

Note: 1. Alberts & Altmann (2011). 2. Cheney & Seyfarth (2007). 3. Huber et al. (2015). 4. Altmann, (1980). unmarked behaviors are from an ethogram provided by C.A.R.E.

Data Analysis

I assessed the dominance rank of 17 individuals (9 females and 8 males) by constructing a winner-loser matrix of dyadic agonistic interactions. I used a David's Score (DS), which calculates rank via the proportions of winning and losing behaviors and is weighted by the wins and losses of other individuals (Huber et al., 2015). I chose the DS method as opposed to the Elo-Rating method, because the latter does a better job of tracking changes in a dominance hierarchy over a longer period of time (Newton-

Fisher, 2017). Moreover, Huber et al. (2015) used the DS method to compare the dominance hierarchy of two differentially reared groups, IUGR (Intrauterine growth restriction, researchers restricted nutrients fed to pregnant and lactating *Papio hamadryas* mothers causing IUGR offspring) and a control group (fed *ad libitum*). In this study, I compared the ranks of three differentially reared groups (HR, SR, and MR). Dominance related behaviors used for the DS analysis included displace, avoid, cower, flee, grimace, keck, scream, and tail up. To calculate DS, I used the EloRating package with the DS function (Neumann, 2020) and conducted tests in R version 1.2.5033 (R Development Core Team, 2019)

To test my first prediction (i), that mother-reared individuals occupy higher positions in the dominance hierarchy than surrogate-reared individuals and surrogate-reared individuals occupy a higher ranked position in the dominance hierarchy than hand-reared individuals, I used a Kruskal-Wallis test to assess differences in median DS between groups. For my next two predictions (i.e., that (ii) SR females will rank adjacent to their surrogate mother, and (iii) SR males will rank adjacent or above their surrogate mother and other females ranks, I decided to forego formal analysis due to the small sample size. Instead, I described where each bonded individual ranked in comparison to their surrogate mother (ranking either above, adjacent to, or below her).

I used generalized linear mixed models with a binomial distribution and a logit link function to test prediction (iv), that mother-reared individuals participate in more affiliative interactions than surrogate-reared individuals do, and surrogate-reared

individuals participate in more affiliative interactions than hand-reared individuals do. Individual ID was designated as a random factor, and rearing history (ordinal, HR, SR, or MR), rank (binary, high or low (I assigned individuals as high or low rank based on whether they were above or below the mean DS (7.99) of the whole troop)), kin (binary, absent or present), sex (binary, male or female), and age (ordinal, juvenile, subadult, or adult) were set as fixed factors in the model (see Table 4). I also used a GLMM with a binomial distribution and logit link function to test prediction (v) hand-reared individuals will participate in more agonistic interactions than surrogate-reared individuals do, and surrogate-reared individuals will participate in more agonistic interactions than mother-reared individuals do. individuals. I calculated the frequency of interactions between individuals using agonistic behaviors (see Table 4). Rearing history (ordinal, HR, SR, or MR), rank (binary, high or low), kin (binary, absent or present), sex (binary, male or female), and age (ordinal, juvenile, subadult, or adult) were set as fixed effects for this model, and ID was designated as the random factor. I based my GLMM analysis off of a study that observed the affiliative and agonistic interactions of chimpanzees (*Pan troglodytes*) (Webb, Romero, Franks, & de Waal, 2017). Webb et al. (2017) used a GLMM to estimate how bystander identity affected the probability of providing consolation. Here, I used a GLMM to estimate the effect that individual identity had in participation of either affiliative or agonistic behavior.

Table 4.

Description of Variables used in GLMM Analysis

Name	**Type**
Dependent variable	
Affiliative	Dichotomous (1 = occurred, 0 = did not occur)
Agonistic	Dichotomous (1 = occurred, 0 = did not occur)
Fixed Explanatory Variables	
Rank	Dichotomous (1 = high, 2 = low)
Rear	Ordinal (1 = HR, 2 = SR, 3 = MR)
Kin	Dichotomous (0 = no kin, 1 = kin present)
Sex	Dichotomous (1 = male, 2 = female)
Age	Ordinal (1 = juvenile, 2 = subadult, 3 = adult)
Random variables	
Individual ID	Nominal

All tests were two-tailed, and significance levels were set at $\alpha = 0.05$. Because sample sizes were small, I calculated exact *p* values (Mundry & Fischer, 1998). I conducted all statistical analyses in R version 1.2.5033, and the GLMM was carried out using the lme4 package (R Development Core Team, 2019).

CHAPTER IV

RESULTS

A total of 169 hours of behavioral data was collected from 17 individuals (for group composition, see Table 3 and 4) from 02 July 2019 to 05 September 2019. These 17 individuals belong to one of three rearing categories: HR (n= 11), SR (n=3), or MR (n=3). Because both sexes were not represented in each rearing group, this skewed the results. Similarly, age was not equally distributed. To account for this in the analyses, I sequentially tested the significance of each variable with the frequency of participation in the behavior.

(i) Mother-reared individuals occupy higher positions in the dominance hierarchy than surrogate-reared individuals and surrogate-reared individuals occupy a higher ranked position in the dominance hierarchy than hand-reared individuals.

The Kruskal-Wallis test was conducted to assess the differences in media DS score between HR, SR, and MR groups. There were no significant differences (chi-squared = 0.62, df = 2, p-value = 0.73) between the three rearing groups.

(ii) Surrogate-reared females will rank adjacent to their adoptive mothers

&

(iii) Male surrogate-reared individuals will rank adjacent to or above their surrogate mothers and above other females ranks.

There were a limited number of individuals in the bonded rearing group (n = 3; 2 males, 1 female). The female (RA) bonded into the troop followed youngest ascendency, ranking just below her surrogate mother (VI), thereby outranking her surrogate mothers' biological daughter (VE) as well as her bonded 'son' (QU). QU, a subadult bonded to VI, also outranked her (VI) biological daughter (VE). Surrogate reared individual AP also outranked his surrogate mother AL.

(iv) Mother-reared individuals will participate in more affiliative interactions than surrogate-reared individuals do, and surrogate-reared individuals will participate in more affiliative interactions than hand-reared individuals do.

The GLMM analysis indicated that rearing history did not have an effect on the frequency of affiliative behavior (see Table 5). Low-ranked individuals did, however, show a trend towards participating in more affiliative behavior (parameter coefficient estimate (mean +/- SE), 1.35 +/- 0.71, z = 1.90, $p = 0.058$, see Table 5 and Figure 1). Additionally, females participated in significantly more affiliative behaviors (parameter coefficient estimate (mean +/- SE), 2.45 +/- 0.39, z = 6.30, $p < 0.001$; see Table 5 and Figure 2).

Table 5.

Results for each Factor Tested in the GLMM Affecting the Likelihood of Participating in Affiliative Behavior

Variable	Estimate	SE	Test Statistic	*P* value
Fixed Effects			*Z*	
Rearing				
(Intercept)	1.47	0.45	3.22	0.001
Surrogate Reared	0.61	0.96	0.63	0.522
Mother Reared	1.04	0.96	1.08	0.279
Rank				
(Intercept)	1.16	0.47	2.45	0.001
Low-Rank	**1.35**	**0.71**	**1.90**	**0.058**
Age				
(Intercept)	3.73	1.46	2.55	0.010
Subadult	-1.86	1.63	-1.14	0.253
Adult	-2.15	1.52	-1.41	0.158
Sex				
(Intercept)	3.73	0.43	0.27	0.117
Female	**2.45**	**0.39**	**6.30**	**<0.001***
Presence of Kin				
(Intercept)	1.35	0.44	3.03	0.002
Kin Present	1.21	0.75	1.61	0.106

*Represents significant values.

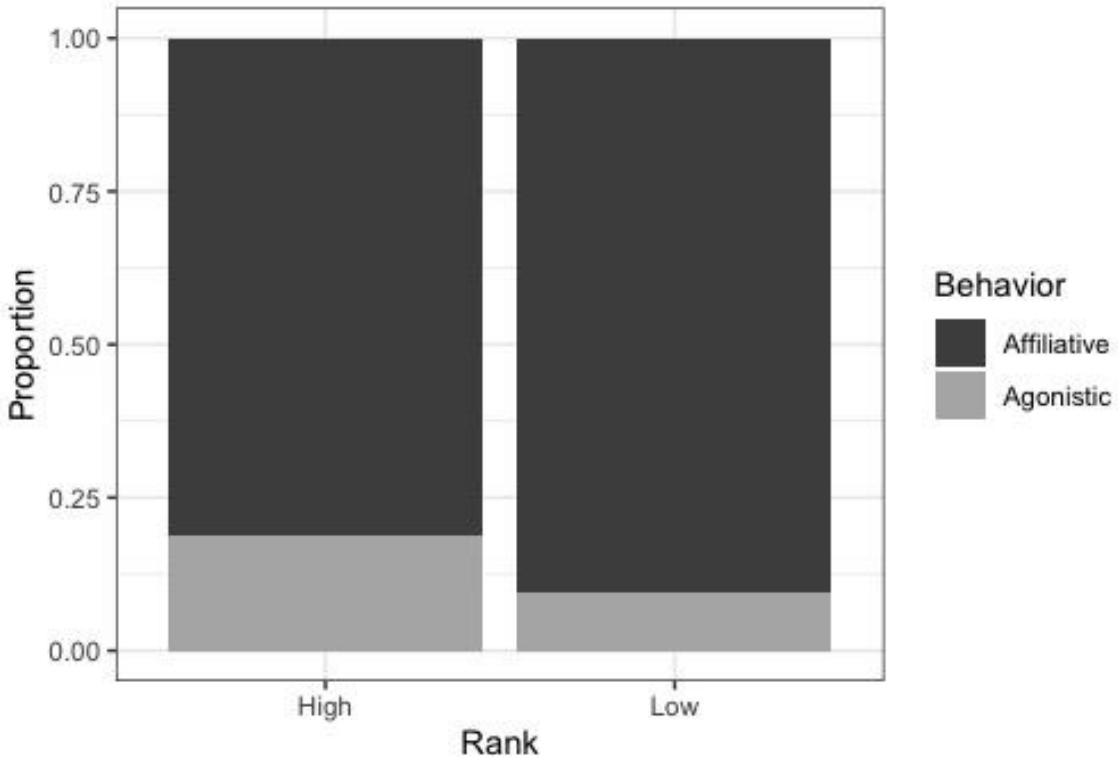

Figure 1.

Proportion of Participation in Affiliative and Agonistic Interactions between high (n=10) and low-ranked (n=7) individuals

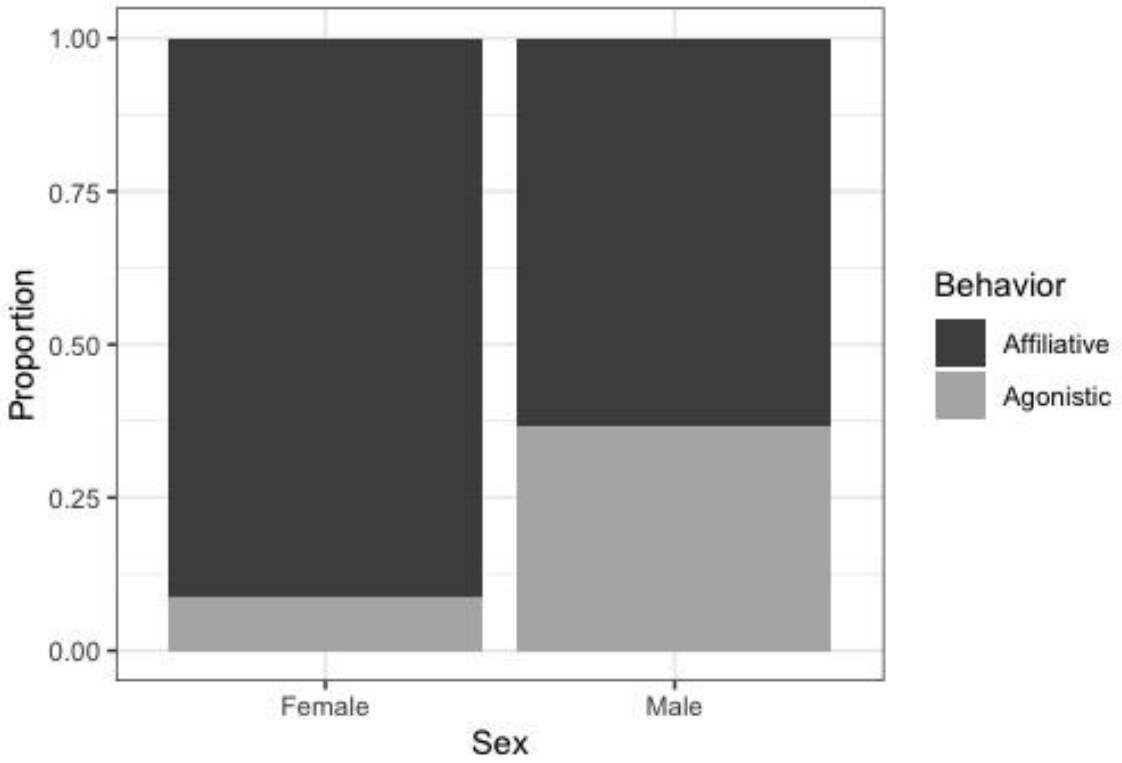

Figure 2.
Proportion of Participation in Affiliative and Agonistic Interactions between females (n=9) and males (n=8)

(v) Hand-reared individuals will participate in more agonistic interactions than surrogate-reared individuals do, and surrogate-reared individuals will participate in more agonistic interactions than mother-reared individuals do.

There was no significant difference between agonistic behavior and rearing group in the agonistic GLMM (see Table 6). However, there was a trend in which low-ranking individuals participated in less agonism than high-ranking individuals (parameter coefficient estimate (mean +/- SE), -1.34 +/- 0.70, z = -1.90, p = 0.057; see Table 6 and

Figure 1). Females participated in significantly less agonism (parameter coefficient estimate (mean +/- SE), -2.45 +/- 0.39, z = -6.30, p <0.000; see Table 6 and Figure 2). Lastly, individuals with kin present in the troop participated in significantly less agonism (parameter coefficient estimate (mean +/- SE), -1.80 +/- 0.72, z = -2.48, p = 0.013; see Table 6 and Figure 3).

Table 6.
Results for each Factor Tested in the GLMM Affecting the Likelihood of Participating in Agonistic Behavior

Variable	Estimate	SE	Test Statistic	*P* value
Fixed Effects			*Z*	
Rearing				
Intercept	-1.47	0.45	-3.22	0.001
Surrogate Reared	-0.61	0.96	-0.63	0.522
Mother Reared	-1.04	0.96	-1.08	0.279
Rank				
(Intercept)	-1.16	0.47	-2.45	0.0140
Low-Rank	**-1.34**	**0.70**	**-1.90**	**0.0576**
Age				
(Intercept)	-3.73	1.48	-2.52	0.0117
Subadult	1.86	1.64	1.13	0.2577
Adult	2.15	1.54	1.39	0.1634
Sex				
(Intercept)	-0.43	0.27	-1.56	0.117
Female	**-2.45**	**0.39**	**-6.30**	**<0.001***
Presence of Kin				
(Intercept)	-1.24	0.38	3.22	0.001
Kin Present	**-1.80**	**0.72**	**-2.48**	**0.013***

*Represents significant values.

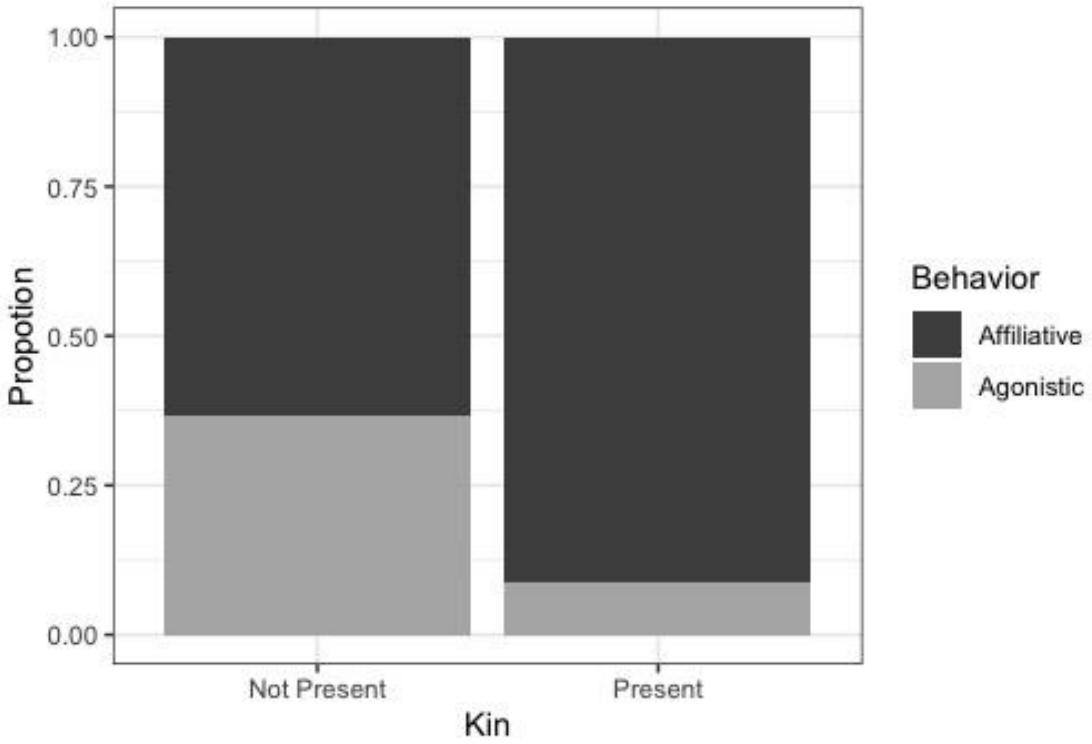

Figure 3.

Proportion of Participation in Affiliative and Agonistic Interactions between Individuals with (n=6) and without Kin (n=11) in the Troop

CHAPTER V

DISCUSSION

I analyzed a variety of factors (dominance rank, social behavior, rearing history, age, sex, and presence of kin) to investigate the effects of rearing history on acquisition of rank and development of species-typical behavior in a rehabilitation setting. My preliminary results suggest that although rearing groups did not differ significantly with respect to rank, I did find species-specific patterns in rank acquisition and social behavior. Low-ranked individuals showed a trend toward both participating in more affiliative behavior and participating in less agonistic behavior than high-ranked individuals. Additionally, females were significantly more likely to participate in affiliation than males and were significantly less likely to participate in agonistic behavior. Lastly, my preliminary findings align with kin-related patterns in agonistic behavior, as individuals who had kin present in the troop participated in significantly fewer agonistic interactions.

Rearing History

There was no significant difference in mean David's Score between the hand-reared group, surrogate-reared, and mother-reared group ranks. Moreover, the GLMM analysis did not suggest that rearing history had any effect on the frequency of participation in affiliative or agonistic behaviors. This highlights the similarities of social behavior between groups and encourages the continued use of current rearing methods in place at C.A.R.E. However, surrogate-reared individuals ranked where one would

expect them to with respect to their surrogate mother's rank (i.e. above, adjacent, or below her rank). Lea, Learn, Theus, Altmann, & Alberts (2014) studied the departures from expected rank acquisitions in yellow baboons, specifically, what factors influenced whether a female followed youngest ascendency, ranked adjacent to other females in her matriline, or ranked below her. One of their findings was that maternal presence influenced whether a female daughter followed youngest ascendency. Additionally, if a female's mother was the highest ranked in her matriline, she would also be likely to follow youngest ascendency.

Youngest ascendancy is a common occurrence in cercopithecines and means that daughters will be inversely ranked, as the younger female will outrank the older. Surrogate-reared individual RA ranks in youngest ascendency to her surrogate-reared mother (VI), which we would expect to see if RA were her surrogate mother's (VI) offspring. Similarly, in wild populations of vervets (*Cercopithecus aethiops sabaeus*), the youngest daughter will outrank the older daughter (Horrocks & Hunte, 1983). Schulman & Chapais (1980) found that in rhesus macaques (*Macaca mulatta*), youngest ascendency may occur because the younger daughter has more reproductive value than the older daughter, and the mother then allocates her time and energy on ensuring the survival of the younger daughter. My results align with these, as RA ranks directly below her surrogate mother (VI) who is the highest-ranked female. Additionally, because

surrogate-reared individuals QU and RA outrank VI's biological daughter (VE), thereby following youngest ascendency, VI is treating these surrogate-reared individuals as her own offspring and focusing the most energy on the youngest individual.

Unlike females who seldom experience rank reversals, male rank is variable. Prior to sexual maturity, male rank is based off of their mother's rank, their own age, and their fighting ability (Hamilton & Bulger, 1990). Once mature, most males will emigrate from their natal troop, and those who do not vie for rank within that troop. In wild populations, immigrating males participate in agonistic interactions to establish their rank within their new troop. Because QU is a subadult male bonded to the highest-ranking female, once he reaches adulthood, he will likely rank above his surrogate mother (VI), and perhaps once fully grown, vie for the alpha position. Additionally, AP (subadult) already outranks his surrogate mother (AL), a low-ranking female, and he is higher-ranked than the lowest-ranking female (JA). This is congruent with the literature, that states that immature male baboons outrank low-ranked adult females (Pereira, 1988). Wooddell, Kaburu, Murphy, Suomi, & Dettmer (2017) found species-typical rank acquisition in Japanese macaques (*Macaca fuscata*) groups in which individuals were permanently separated from their mothers and living with peers. Similarly, in this study, I observed that surrogate-reared individuals acquired rank in a species-typical manner.

Due to the limited amount of time during which I was able to collect data, I decided to focus my observations on one troop. I wanted to ensure that I recorded an adequate amount of behavioral data to get a snapshot of the dominance hierarchy

within this troop. Additionally, one of C.A.R.E.'s methods of rehabilitation involves keeping troop sizes relatively small. While chacma baboons can average living in troops upwards of 50 individuals, most of the troops at C.A.R.E. have fewer than 30 individuals. This method is utilized so that once released, troops can merge with wild troops to learn locations of food, water, and safe sleeping sites. I had a small sample size (n=17 individuals), and while my data analysis revealed rearing history did not affect dominance rank or social behavior, future research should examine multiple troops to more definitively understand the extent to which skewed group size affects the results and if a relationship between rearing history and rank exists.

Affiliative Behavior

In my study troop, low-ranking individuals show a trend toward participating in more affiliative behavior. In baboon society, there is a skewed distribution of resources. High-ranking individuals have priority of access to food, water, sleeping sites, and mates. They often use agonistic threats to dissuade low-ranking individuals from attempting to access these valuable resources. Low-ranking individuals solicit high-ranking individuals using affiliative behaviors such as grooming for access to these resources (Alberts & Gaillard, 2018). My results of low-ranking individuals showing a trend towards participating in more affiliative behavior thereby aligns with the species-typical behavior of a wild troop, as low-ranked individuals are likely soliciting high-ranked individuals using affiliative behaviors for access to resources.

Another explanation for this trend could be because low-ranked individuals are subject to higher cortisol concentrations when there is little opportunity for social affiliation, and when stress in the troop is high (Abbott et al., 2003). Individuals who experience less social affiliation may experience higher basal cortisol concentrations. Increased social affiliation such as grooming and grunting with preferred partners helps to mitigate the harmful effects of stress (Crockford et al., 2008) and could be an adaptive way low-ranked individual deal with stress in my study troop.

My results also reveal that females participate in significantly more affiliative behaviors than males. This finding aligns with current literature as most of the time, female rank reversals are quite rare, and a female's rank within her troop is based on their mother's rank (Cheney & Seyfarth, 2007). Daughters normally rank adjacent to their mothers, thereby outranking all females who rank below their mother (Engh, Hoffmeier, Seyfarth, & Cheney, 2009). This means that females can spend more time participating in affiliative interactions rather than fighting over the dominance hierarchy. Additionally, female Amboseli baboons spend up to 15% of their activity budget in affiliative social behaviors such as grooming (Alberts & Gaillard, 2018). Moreover, according to Noë and Slujter (1995), while yellow and olive male baboons participate in alliances with other males, male alliances in chacma baboons are non-existent. Therefore, higher frequencies of affiliative behavior and lower frequencies of agonistic behavior in females than males observed in my study are congruent with the literature based on wild populations.

Lastly, there are three individuals in the mother-reared group in this troop, all of whom are female. For this reason, the mother-reared group has a skewed sex ratio. While it is species-typical for females to participate in more affiliative behavior, the GLMM analysis may have exaggerated the results between sex and participating in affiliative behavior.

Agonistic Behavior

I found that low-ranking individuals show a trend toward participating in less agonistic behavior than high-ranking individuals. This could also be explained by the fact that high-ranking individuals have first pick when it comes to limited resources (Alberts & Gaillard, 2018). Because of this priority access to resources, high-ranked individuals can use agonistic threats to maintain that access to resources and moreover, can displace agonism onto low-ranking individuals (while low-ranking individuals, don't have that outlet) (Sapolsky, 1995; Crockford, Wittig, Whitten, Seyfarth, & Cheney, 2008). Since low-ranked individuals do not have the same opportunities to cope with stress they receive through displaced agonism, they do not participate in agonism as much as high-ranked individuals. This is another explanation as to why low-ranking individuals show a trend of participating in less agonism than high-ranking individuals: low-ranking individuals will likely receive agonistic threats or actions when attempting to gain access to resources as well as receiving displaced agonism from high-ranking individuals.

Finally, individuals are significantly less likely to participate in agonistic behaviors when kin are present. Abbott et al. (2003), surveyed several primatologists who study

different primate species (common marmosets [*Callithrix jacchus*], cotton top tamarins [*Saguinus oedipus*], squirrel monkeys [*Saimiri scurieus*], rhesus macaques [*Macaca mulatta*], talapoin monkeys [*Miopithecus talapoin*], cynomolgus monkeys [*Macaca fasicularis*], and olive baboons [*Papio Anubis*]) to understand how the society in which individuals live can predict stress responses. Using a questionnaire, they found that individuals who experience frequent stress, have little opportunity for social support, and few to no kin present in their society have more frequent activation of the stress response. Individuals who experience increased rates of affiliation experience less stress, as affiliative support can help to mitigate the negative effects of the stress response (Crockford et al., 2008). Females tend to focus their grooming on close kin (Cheney & Seyfarth, 2007). While my results did not indicate that those with kin participate in significantly more affiliative interactions, they did participate in significantly less agonism. This could suggest that they experience less stress in the troop and are therefore less susceptible to stress-related illness as instead of participating in agonism, they focus their time on affiliative behaviors. Another study found that female chacma baboons focus their grooming networks on preferred partners during unstable periods in the dominance hierarchy to cope with instability (Wittig, Crockford, Lehmann, Whitten, Seyfarth, & Cheney, 2008), and these preferred partners are usually kin as kin increase the frequency of affiliation and support.

Future Directions

Ebua et al. (2014), state that documentation of rehabilitation procedures is crucial to build effective guidelines for rehabilitation and reintroduction of primate species. Here, I documented two rearing methods in the rehabilitation setting and how they affect these individuals' rankings and affiliative and agonistic social behaviors. In the future, each stage of rehabilitation should be documented to assess species-typical behavior as a measurement of readiness for release. Additionally, Ebua et al. (2014), took pre-release observations on individuals including human avoidance and group cohesion behaviors as criteria to meet prior to release. Moving forward, when evaluating rearing method effects long term, including data on both of these factors would be beneficial to understand if surrogate-reared individuals show more or less interest in human interaction, and are better integrated into the troop than are hand-reared individuals. Since each individual (other than the mother-reared group) had exposure to humans in varying degrees as infants, assessing approach and avoidance of humans while in Phase II of rehabilitation may help us to understand how individuals may react to human encounters post-release.

While the purpose of rehabilitation for release is to help to re-establish an extinct wild population or to add to a declining wild population (Beck, Walkup, Rodrigues, Unwin, Travis, & Stoinski, 2007), it is important that the practices in use prior to release are also beneficial and cause little to no physiological or psychological harm. Individuals in the hand-reared group spent between 6 – 12 mos. with human contact as

infants prior to moving into the hands-off phase of rehabilitation. Using the surrogate-rearing method, infants can move into the hands-off phase of rehabilitation after 3 months and be released with their new troop far sooner than would occur using the hand-rearing method. Reducing human contact earlier in life is thought to be a beneficial and more ethical practice to ensure that once released, individuals more easily disassociate human presence with food, comfort, and shelter.

Tung, Archie, Altmann, & Alberts (2016), found that early life adversity, mainly maternal loss and presence of sibling(s) competing for resources, is connected to a shorter adult lifespan in female baboons. Moreover, early life adversity also predicted social isolation from females in adulthood, which is also indicative of a shorter lifespan. However, females who experienced social isolation from females could form social relationships with males, potentially avoiding the detrimental effects of early life adversity. In my study troop, apart from two individuals born into the troop, each troop member lost his or her mother early in life. Bonding orphaned infants to surrogate baboon mothers may help to prevent early morbidity via replacing that maternal relationship with a surrogate. My results indicate that surrogate-rearing is a successful rehabilitation practice for infants who have lost their mothers and troops. Using a surrogate mother may also help by allowing individuals to interact with conspecifics and form close relationships within the troop, avoiding social isolation as individuals can begin to form close bonds with conspecifics earlier in life. Future research should assess

longevity and morbidity between different rearing groups to further understand if surrogate mothers help to prevent early death.

The surrogate-rearing process was adopted and adapted by C.A.R.E. staff with advice from Lilongwe Wildlife Trust (LWT), a wildlife rehabilitation and reintroduction facility based in Malawi. While I found no difference between individuals based on rearing history, if the resources are available, surrogate-rearing may be the more ethical approach. Not only does it provide a mechanism to replace the mother infant bond and allow adult females to practice mothering behavior, it also lessens the amount of time that individuals spend with humans. This is important because we do not want to propagate elongated contact with wild animals, as images of infant primate care in rehabilitation centers can increase the pet trade (Norconk, Atsalis, Tully, Santillán, Waters, Knott, Ross, Shanee, & Stiles, 2019). According to the Best Practice Guidelines for the Reintroduction of Great Apes, reducing human contact is an important part of the rehabilitation process as individuals being released should be able to independently survive in the wild (Beck et al., 2007). Guy and Curnoe (2013), created Rehabilitation and release guidelines for vervet monkeys (*Chorocebus aethiops*) and specify that prior to release human contact should be minimal as many primates can contract human diseases and vice versa. Individuals who are surrogate-reared will most likely spend less time in captivity overall than hand-reared individuals. In the past, hand-reared individuals were normally integrated into troops that contained similar aged infants and juveniles. Out of concern for the baboons' survival, C.A.R.E. would not release a troop

until a majority of the troop members were full grown. Surrogate-reared individuals are bonded into troops where the majority are full grown, allowing for the surrogate-reared individuals to be released far sooner than they would be if using the hand-rearing method. My finding no difference between rearing histories also means that the surrogate-rearing process works, and individuals are presenting species typical behavior across groups. Moving forward, we should continue to utilize this process in situations where there are adult females available to take on infants.

Understanding differences in social behavior between the two rearing types may help us to understand potential underlying physiological health concerns long term. Exposure to stress can have deleterious effects on health. An unstable dominance hierarchy, individuals who participate in less social affiliation, experience more agonism, and have less kin present, usually experience higher basal cortisol concentrations (Sapolsky, 1995). Using fecal or urinalysis, future studies could assess individual's susceptibilities to stress related illness given different rearing histories.

Conclusion

In this study, I sought to understand how bonding individuals to surrogate conspecific mothers affects an individual's social behavior and her or his dominance rank in troops, and what the implications of the results might mean with respect to underlying health. In the process, I found that the surrogate-rearing method used at C.A.R.E. is a successful rehabilitation tactic as surrogate-reared individuals rank acquisition follows the expected trajectories of their adoptive mothers. Moreover, I

found no significant differences in the affiliative and agonistic GLMMs between rearing groups, which suggests that individuals are behaving in a species-typical manner.

Across South Africa alone, there are several rehabilitation centers using different methods when it comes to rearing rescued orphans. Here I assessed the two rearing methods that have been implemented at C.A.R.E now and in the past. These include hand-rearing in which the infant would spend the first 6 to 12 months with a human surrogate before a troop of similar aged conspecifics was created, and surrogate-reared in which the infant had a human-surrogate for the first 3 months of life before being bonded to an adult female and later integrated into her troop with her. Additionally, I included individuals that were born into the troop (mother-reared) to fully assess the troops rearing histories. C.A.R.E. has moved away from hand-rearing infants not only because of a lack of individuals available to create peer-groups, but also because of concerns with respect to baboons' dependency on humans for food, water, shelter, and care. Our involvement in the rearing or rehabilitation process and how that affects individuals in the long term is not well studied. My study provides vital preliminary results from observations on differentially reared individuals at C.A.R.E. to explore rearing history's effects on rank acquisition and species typical patterns of affiliative and agonistic behavior and one of the few helping rehabilitation center staff to make evidence-based decisions. When considering that these individuals will one day be released back into the wild, their dominance hierarchies and social behavior should closely mirror a wild troop. My analyses indicate that surrogate-reared individuals do

indeed show similar behavioral patterns as their wild counterparts, and therefore surrogate-rearing is a viable method of rearing individuals in captivity.

The number of rehabilitation centers in South Africa alone, coupled with the increasing number of rescued individuals living on site awaiting release (over 400 at C.A.R.E.), speaks to the impact that our species has had on chacma baboons. Our means of conserving the decreasing wild population through reintroduction practices need to ensure the ultimate well-being of each individual during both pre- and post-release. Overinvolvement of humans in infants' lives is propagating the wrong message to those outside the rehabilitation and conservation communities and can increase the number of primates in the pet trade. Our responsibility to reintroduce troops back into the wild needs to ensure that our involvement does not cause further detriment. There is incredible value in continuing to evaluate current methods in use as well as evaluating how our involvement impacts baboons throughout their lives. Given the results of my preliminary study and the efficacy of surrogate-rearing, this method should be used over hand-rearing. While resources may not always be available, those who can utilize surrogate-rearing set an example for existing rehabilitation centers and conservationists. Human interference in these animals' lives caused the loss of their family and freedom, surely, we owe them no further detriment and as normal a life as we can provide.

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