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Managing Sociality of a Captive Female Bornean Orangutan from Breeding to Post-partum at The Smithsonian's National Zoo

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A thesis submitted in partial fulfillment of the requirements for the degree of
Master of Science at Virginia Commonwealth University.

by

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Abstract

MANAGING SOCIALITY OF A CAPTIVE FEMALE BORNEAN ORANGUTAN FROM BREEDING TO POST-PARTUM AT THE SMITHSONIAN'S NATIONAL ZOO

By Marie Vergamini, M.Sc.

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science, at Virginia Commonwealth University.

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The Association of Zoos and Aquariums' Orangutan Species Survival Plan® aims to maintain 100 Bornean orangutans (*Pongo pygmaeus*) in captivity. Because investment in breeding these lineages is high, properly managing sociality of potential mothers is essential. This study assessed how behaviors of a captive breeding female at the Smithsonian's National Zoo changed from pre-gestation through the offspring's sixth month of age to improve breeding recommendations.

The infant Bornean orangutan was born September 2016. Results indicate that during breeding, the mother socialized most with two adult females. During pregnancy, the pregnant female socialized in less energy-consuming ways, i.e. grooming. Post-partum socialization and proximity data suggest a shift in female affiliation. The presence of another female with maternal experience may be beneficial to the rearing of new offspring. These results can help guide socialization management for pregnant captive orangutans to improve breeding outcomes.

Introduction

There is extensive research on the social intricacies of orangutans in captivity and how effective orangutan husbandry practices allow zoo-housed orangutans to be more gregarious than wild orangutans (e.g. Martin, 1981; Seuánez, 1982; Markham, 1990; Field et al., 1998; Cocks, 2007; Anderson et al., 2008). Conversely, there is a lack of long-term studies on zoo-housed Bornean orangutan (*Pongo pygmaeus*) females from breeding to post-gestation and even less literature on how to foster breeding environments (but see Sodaro et al., 2006). The Association of Zoos and Aquarium's (AZA) Bornean Orangutan Species Survival Plan® projects that the North American captive population is at risk of extinction if breeding is not facilitated (AZA Bornean Orangutan SSP®, 2017). This requires breeding pairs to be placed in institutions that can provide a successful breeding and rearing environment for mother and offspring. The current study addresses the gap in the literature by analyzing the behaviors and social network of a captive Bornean orangutan female housed in a complex, mixed-sex group of Bornean and hybrid orangutans at the Smithsonian Institution's National Zoo (NZP) during breeding, pregnancy, and raising her offspring.

The Bornean orangutan (*Pongo pygmaeus*) is a Great Ape species found throughout the island of Borneo. As the most arboreal of the apes, they generally live in the trees as their prehensile feet, elongated hands, small thumbs, and long forelimbs allow for easy movement through their wetland habitats (Pomerantz et al., 2013). They are diurnal and are most likely to be active at dawn and early afternoon and build nests in trees every night (Morrogh-Bernard et al., 2009). Wild Bornean orangutans spend the majority of their days in the trees, only to come down from the canopy for rare food finds or loss of habitat due to the palm-oil industry.

They are primarily frugivores who search for high energetic and nutrient-rich foods.

According to Morrogh-Bernard et al. (2009), orangutans in the wild allocate approximately 50% of their activity budget foraging for food, 40% traveling, and the remaining 10% resting, socializing, mating, and other behaviors. During high-fruit seasons, fruits comprise nearly 100% of a wild orangutan's diet (Bastian et al., 2010). Their slow metabolism allows orangutans to easily gain weight during low-fruit seasons. Since fruits are seasonal, they have adapted to supplement the fruit with leaves, bark, flowers, insects, and some small mammals (Bastian et al., 2010).

Wild Bornean orangutans live solitary to semi-solitary lives and rarely live in groups. Females give birth on average every eight years, gestation is around 254 days, and offspring dependency lasts six to eight years (Galdikas, 1981). Males disperse from their natal groups once they reach sexual maturity, whereas a female may stay with her mother longer. Males experience two stages of puberty where in the second stage they develop pronounced cheek phalanges, increase in weight, and hair growth (Dixon et al., 1991).

The current population of wild Bornean orangutans is on the decline due to drastic human modifications to the landscape. Accounting for 74.2% of population decline, deforestation for timber plantations and habitat degradation from logging have resulted in habitat loss, particularly in peat swamp forests (Ancrenaz et al., 2016). Bornean orangutans have been assessed as critically endangered by the IUCN's Red List and the species' population will decline by 80%by 2025 (Ancrenaz et al., 2016).

With wild populations on the decline, North American zoos are emphasizing conserving captive populations. The Association of Zoos and Aquariums' (AZA) Orangutan Species Survival Plan® (SSP®) aims to sustain 100 Bornean orangutans of maximum genetic diversity (AZA Ape Taxon Advisory, 2015). This Great Ape species have been the subject of a wide range

of behavioral and cognitive studies that look to better husbandry practices and explore links to human evolution. There are currently 52 North American institutions participating in the SSP® breeding program sustaining Bornean orangutan populations. Due to long childhood dependency of about eight years and long interbirth intervals (Galdikas, 1981), captive populations are also at risk for extinction. To counter this, the SSP® Breeding and Transfer Plan recommends an average of five births per year throughout the North American captive population (AZA Ape Taxon Advisory, 2015).

In order to successfully rear Bornean orangutan offspring, breeding pairs must first be matched based on compatible orangutan personalities (Perkins, 1992). The pairs are then moved to a zoo that can provide the appropriate environment to facilitate successful breeding. The Orangutan Care Manual does not give details on how to increase compatibility or reproductive success. However, it encourages keeping the breeding pair in the same space when the female is in estrous. This guide mainly focuses on secondary rearing options if the infant is rejected or not able to be cared for by the mother (AZA Ape Taxon Advisory, 2015).

In 2016, a breeding pair at Smithsonian's National Zoo successfully bred and the female, Batang, gave birth to a male offspring. Over a two year span, this focal female's behaviors and social network were studied to better understand how Batang adjusted to being pregnant and raising her infant. Results of this study can also be applied in recommending how husbandry practices can facilitate a full-term pregnancy and healthy rearing of the offspring by the biological mother.

Hypotheses

- Behavior Hypothesis 1: The Orangutan Husbandry Manual suggests that captive pregnant

orangutans will be more agitated, more restless, lethargic, and lose their appetite compared to when they are not pregnant (Sodaro et al., 2006). Test Implication: The pre-pregnancy breeding portion of this study will be used as a baseline for comparisons with pregnancy and post-partum phases to determine significant changes in time spent participating in behaviors. During pregnancy, we expect to see the focal female to rest more compared to the behavioral baseline, resulting in a decrease in time spent foraging and socializing.

- Social Hypothesis 1: During the focal female's pregnancy, she will become less interested in her conspecifics, especially the males. Test Implication 1: There will be a decrease in observed interactions and a shift in the how she socializes with the other adults. Test Implication 2: Female bonds are stronger than male-female bonds for Bornean orangutans, so we anticipate the focal female's most often observed nearest neighbor will be female.
- Behavior Hypothesis 2: During the post-partum phase, the focal female's concerns will be primarily for the care of her infant. Test Implication: Her social behaviors will increase compared to the previous phases, but will be mainly directed towards her infant and interactions with the adult orangutans will be much less than compared to the behavioral baseline. There will be an increase in foraging from the pregnancy phase to complement the extra nutrition she will need to nurse. There will be a decrease in rest behaviors compared to the pregnancy phase but an increase from the breeding phase.
- Social Hypothesis 2: Once the focal female is raising her infant, her social interactions and proximity will be to the infant. Test Implication: Her choice in which adult orangutan is nearest to her will be more influenced by their interest in the infant rather than the

interest of the focal female. Therefore, we expect that the only adult orangutan with previous maternal experience to remain the closest to the focal female and offspring.

Significance of Results

The IUCN's Red list categorizes Bornean orangutans as a critically endangered species and sustaining a stable orangutan population in North American zoos is important to the conservation and survival of this species (Ancrenaz et al., 2016). It is important to better understand the complex social network and behavioral changes of captive breeding females in order to successfully facilitate a comfortable breeding and rearing environment for the female. During the time of this study, the focal individual successfully bred and is rearing her offspring. The orangutan husbandry practices and SSP® breeding protocols put in place by the National Zoo's Primate Unit will be discussed in the context of this study. Findings will be shared with AZA's Bornean Orangutan Species Survival Plan®, which manages the population of orangutans in North American zoos and determines breeding pairs.

Materials and Methods

All behavioral data were collected in the Great Ape House and Think Tank at the Smithsonian's National Zoo in Washington, D.C. Data were collected from the focal subject, Batang, Batang's offspring, Redd (once born), and the other five adult orangutans. Husbandry practices remained unaffected by this study. Cleaning, enrichment, training, and other research projects continued as regularly scheduled.

Focal subject

This study follows a 20-year-old female Bornean orangutan, Batang, who is housed at the National Zoo with her year-old offspring and five adult orangutans (Table 1; Fig. 1). Following an AZA SSP® breeding recommendation, breeding pair Batang and Kyle, both born in 1996, were transferred from, respectively, the Topeka Zoo and the Cleveland Metroparks Zoo to the National Zoo in October 2004. As is standard per AZA zoo protocols, Batang was placed on birth control while she acclimated to her new environment and the other primates. When Batang started exhibiting breeding behaviors in 2014, the Primate Unit took her off birth control to allow conception. Primate keepers tracked Batang's cycling using daily urine hormone-level tests and labial swelling. In February 2016, two positive pregnancy tests and an awake sonogram confirmed Batang was pregnant. In April 2016, a sonogram was able to see a healthy fetus developing. On September 12th, 2016, she had a natural, unassisted delivery and gave birth to male offspring, Redd. See Appendix A for a timeline of Batang's life history.

Table 1: Biographical information of NZP's orangutans

Name	Sex	Species	D.O.B.	Indoor Enclosure mates	Outdoor Enclosure mates
Batang	Female	*Pongo pygmaeus*	December 27, 1996	Bonnie, Iris, Kiko, Kyle, Redd	Bonnie, Iris, Kiko, Kyle, Lucy, Redd
Bonnie	Female	Hybrid	December 29, 1976	Batang, Kyle, Redd	Batang, Kyle, Redd
Iris	Female	Hybrid	April 15, 1987	Batang, Kiko, Redd	Batang, Kiko, Lucy, Redd
Kiko	Male	Hybrid	November 24, 1987	Batang, Iris, Redd	Batang, Iris, Lucy, Redd
Kyle	Male	*Pongo pygmaeus*	December 6, 1996	Batang, Bonnie, Redd	Batang, Bonnie, Redd
Lucy	Female	Hybrid	March 2, 1973	Kiko	Batang, Iris, Kiko, Redd
Redd	Male	*Pongo pygmaeus*	September 12, 2016	Batang, Bonnie, Iris, Kiko, Kyle	Batang, Bonnie, Iris, Kiko, Kyle

Figure 1. The orangutans in this study. From left: Batang (focal), Bonnie, Iris, Kiko, Kyle, Lucy, Redd. Photos courtesy of the DC Zoo Walks

National Zoo Orangutan Management

There are two adult flanged orangutans at the National Zoo that are required to be housed separate from each other due to male-male competition. Consequently, there are two main male-female pairs, Bonnie/Kyle and Iris/Kiko. Batang, the "social butterfly" of all the orangutans, spends time with both pairs. Generally, Batang can choose or be asked to shift with either pair. For breeding purposes, while Batang was ovulating, she would be kept with Bonnie/Kyle to increase mating opportunities with Kyle. Kiko, a hybrid orangutan, is sterile, therefore while Batang did copulate with him, the pair could not successfully breed. For the purposes of this study, it is important to note the maternal experience of the other adult females. Bonnie successfully reared Kiko, her biological offspring. Iris has never been pregnant and has not been exposed to mother-infant pairs past her juvenile years until Redd's birth. Lucy has sired two offspring but it is unclear whether she raised them. As there was a possibility that Batang would reject or not be able to raise Redd, Bonnie and Iris received surrogacy training to be potential surrogate mothers to Redd. For example, they were trained to position a stuffed animal close to the enclosure's mesh so that a keeper could bottle-feed a baby.

Habitat

The orangutans are housed in two facilities, the Great Ape house and Think Tank, which are connected by the O-Line Transportation System. The Great Ape House consists of six

adjacent indoor enclosures with three elevated chutes to one outdoor yard (Fig. 2). Renovations to the Great Ape House began in Summer 2016 and were completed in Summer 2017. Access to certain enclosures were affected during this time and noted. Think Tank comprises three indoor enclosures with two doors to one outdoor yard (Fig. 3). Doors are controlled by hydraulics. Since there is less space at Think Tank, the number of orangutans that can stay there is limited. Batang and Redd can be there with either Bonnie/Kyle or Iris/Kiko.

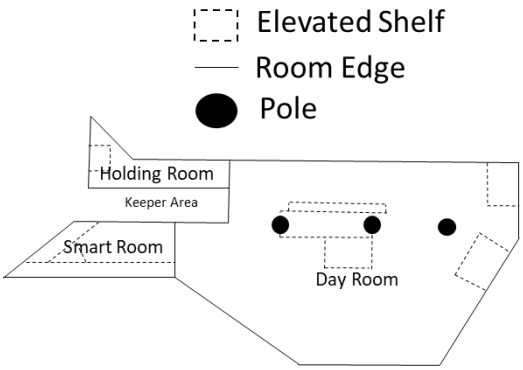

Figure 2. Map of Great Ape House. Orangutans, including the focal female, had variable access to this indoor enclosure throughout the day.

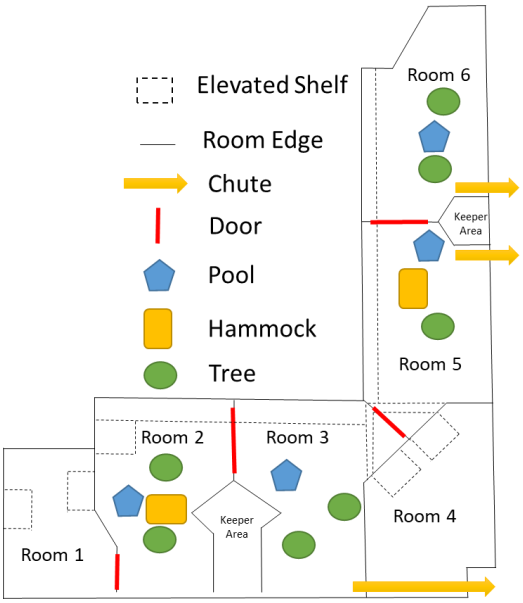

Figure 3. Map of Think Tank. Orangutans, including the focal female, had variable access to this indoor enclosure throughout the day.

The O-Line Transportation System consists of eight fifty-foot towers with platforms connected by cables (Fig. 4). There is a tower in each of the facilities' outdoor yards. The remaining six are stationed on the visitors' side of the yards. These latter towers have electric wiring under the platforms to prevent the orangutans from climbing down. Trees near the towers are trimmed regularly to prevent the orangutans from reaching out and climbing down these trees. The orangutans are given access to the O-Line weather-permitting. They can choose to not travel or not go into the yards. Once outside, they may travel from one yard to the other as many times as they want. Batang was restricted from the O-line for the first three months post-partum until Redd was assessed to be strong enough to latch on to Batang as she traveled across.

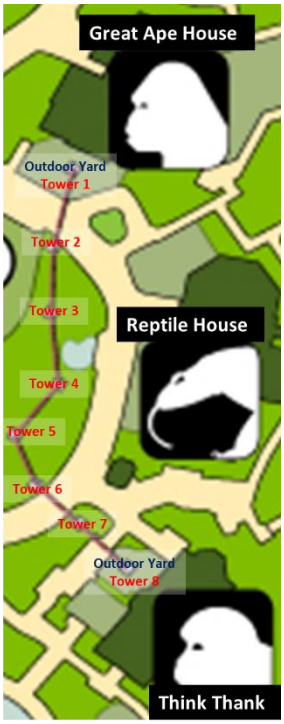

Figure 4. Map of the O-Line Transportation System. The O-Line connects the Great Ape House and Think Tank, and can be used by orangutans to move between locations. Graphic courtesy of Smithsonian's National Zoo.

Data Collection

This study uses the standard protocol outlined by the University of Zurich's Orangutan network, as their methods are commonly used in wild orangutan studies (van Schaik, 2015). Behavioral data from Batang were collected three times a day, three times a week, through 30-minute focal time samples, during which Batang's primary and secondary behavioral state were recorded once every two minutes. Nearest neighbor data sampling, conducted during the same time focal sampling occurred, was assessed once every five minutes. Following Martin and Bateson (2007)'s sampling methods, in order to prevent observer fatigue and loss in concentration without compromising data quality, daily observations were conducted during set time blocks over an eight hour activity period: 7-9 a.m., 9-11 a.m., 11 a.m.-1 p.m., and 1-3 p.m.

Observations were conducted from the Great Ape Keeper hallways and Think Tank public space when Batang was indoors, public outdoor viewing areas when Batang was in the outdoor yards, and from a live feed installed in the Great Ape House during the first month of Batang's offspring's life. No observations were conducted on any day of an orangutan veterinarian examination. If Batang was at Think Tank during the Think Tank Demo that occurs daily from 1:30pm – 2:00pm, data were not collected during this period.

At the beginning of each observation, Batang's location, enclosure access, elevation, enclosure mates, and number of visitors were recorded. Afterwards, at every 2-minute mark for focal sampling and 5-minute mark for nearest neighbor, changes in Batang's location, enclosure access, elevation, and enclosure mates were noted.

In accordance with Dr. Meredith Bastian, Curator of Primates at the Smithsonian's National Zoo, and David Glendinning, Primates research assistant, an ethogram from the University of Zurich's Orangutan network was developed to code a primary behavior and then, when applicable, a secondary behavior (Van Schaik, 2015) (Appendix B). These primary state behaviors, distinctively different from one another, followed a hierarchy: "Social" > "Nest Building" > "Moving Long Duration" > "Feed/Forage" > "Move Short Distance" > "Rest." Secondary behaviors were distinct to their primary behaviors. For example, "Drink Water" is under "Feed/Forage." Behaviors that did not fall under these categories or were deemed abnormal where coded as "Unknown." Any additional behaviors or significant changes were noted in an *ad libitum* data section.

Inter-observer reliability testing was conducted between three data collectors comparing six bouts of data collection. Using Cohen's kappa coefficient, which takes into account chance agreements, researchers were found to be in near perfect agreement in primary and secondary

behavior collection ($\kappa = 0.91$ and $\kappa = 0.89$).

Data Analysis

All statistical tests were conducted using JMP 13. Data were divided into three phases, corresponding with Batang's pregnancy (Table 2). Data were analyzed using ANOVA and also Brown-Forsythe tests to compare group variances as deviations from group medians, and significances are reported at $p<0.05$.

Table 2. Phases of Batang's pregnancy and corresponding periods of data collection

Phase Name	Corresponding dates
Breeding	August 1, 2015 – February 8, 2016
Pregnancy	February 9, 2016 – September 11, 2016
Post-Partum	September 12, 2016 – May 31, 2017

Results

Analysis of Social Behaviors

A total of 282 30-minute focal sessions, or 141 hours of observations, were included in behavioral analyses (Table 3). Each behavior was analyzed based on frequency, representing the number of times that behavior was recorded within a 30-minute focal session. The frequency of "Rest," "Social," and "Feed/Forage" behaviors differed significantly over the phases of this study (Table 4). For the primary behaviors, for each phase, Batang spent the majority of her time resting. During the pregnancy phase, there was an increase in social behaviors and a decrease in forage behaviors. Compared to the pregnancy phase, the post-partum period experienced an

Table 3. Number of focal observations and data collection hours throughout phases of study

Phase	Observations	Hours
Breeding	44	22
Pregnancy	102	51
Post-Partum	136	68

increase in social behaviors.

Throughout the phases, we observed significant increase in social behaviors (Table 4; Fig. 5). Trends in behavioral changes throughout the day can also be identified from the primary behaviors (Fig. 6). Specifically, time spent foraging and resting change throughout the day depending on phase of breeding, with more time spent resting earlier in the day during pregnancy and post-partum phases, and thus more time spent foraging later in the day during these phases.

Taking a closer look at observed secondary social behaviors in the breeding phase, Batang "Interacted with humans" at a rate that was significantly greater than the other behaviors (Fig. 7). Her exchanges with the other orangutans were mostly "Social Play." During the pregnancy phase, "Watching" was most observed, "Social Play" decreased, and "Grooming" increased. As in the pregnancy phase, the post-partum phase was characterized by "Watching." There was also a significant increase in "Other" behaviors compared to breeding and pregnancy.

Table 4. Results of ANOVAs comparing time spent in primary behaviors between phases. *P*-values are significant at <0.05.

Primary Behavior	Phases	*p*-value
Forage	Breeding vs. Pregnancy	>0.05
	Breeding vs. Post-Partum	0.0154
	Pregnancy vs. Post-Partum	0.7006
Rest	Breeding vs. Pregnancy	<0.0001
	Breeding vs. Post-Partum	<0.0001
	Pregnancy vs. Post-Partum	0.5862
Social	Breeding vs. Pregnancy	>0.05
	Breeding vs. Post-Partum	<0.0001
	Pregnancy vs. Post-Partum	<0.0001

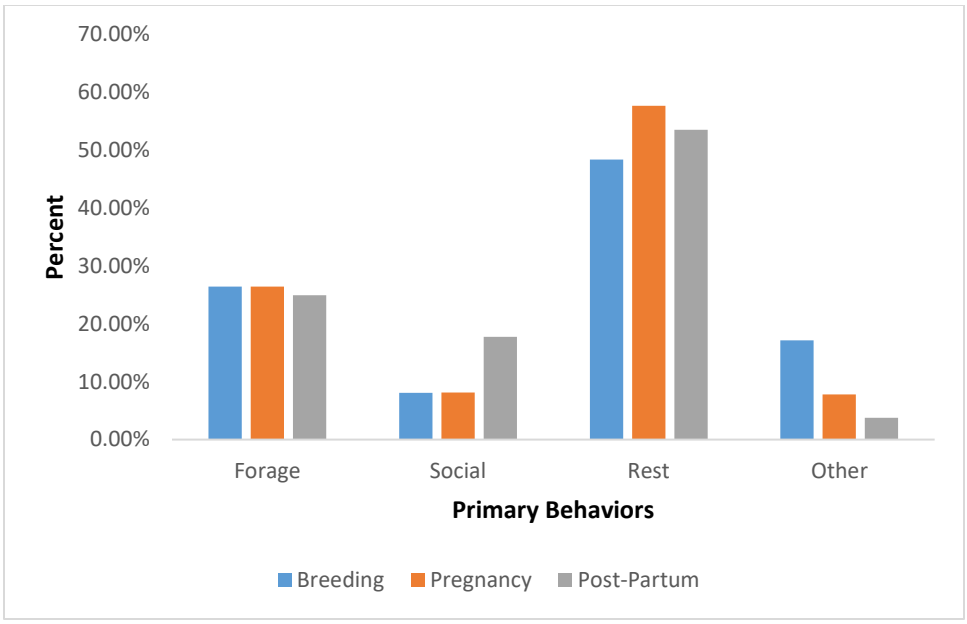

Figure 5. Primary behaviors observed during breeding, pregnancy, and post-partum phases.

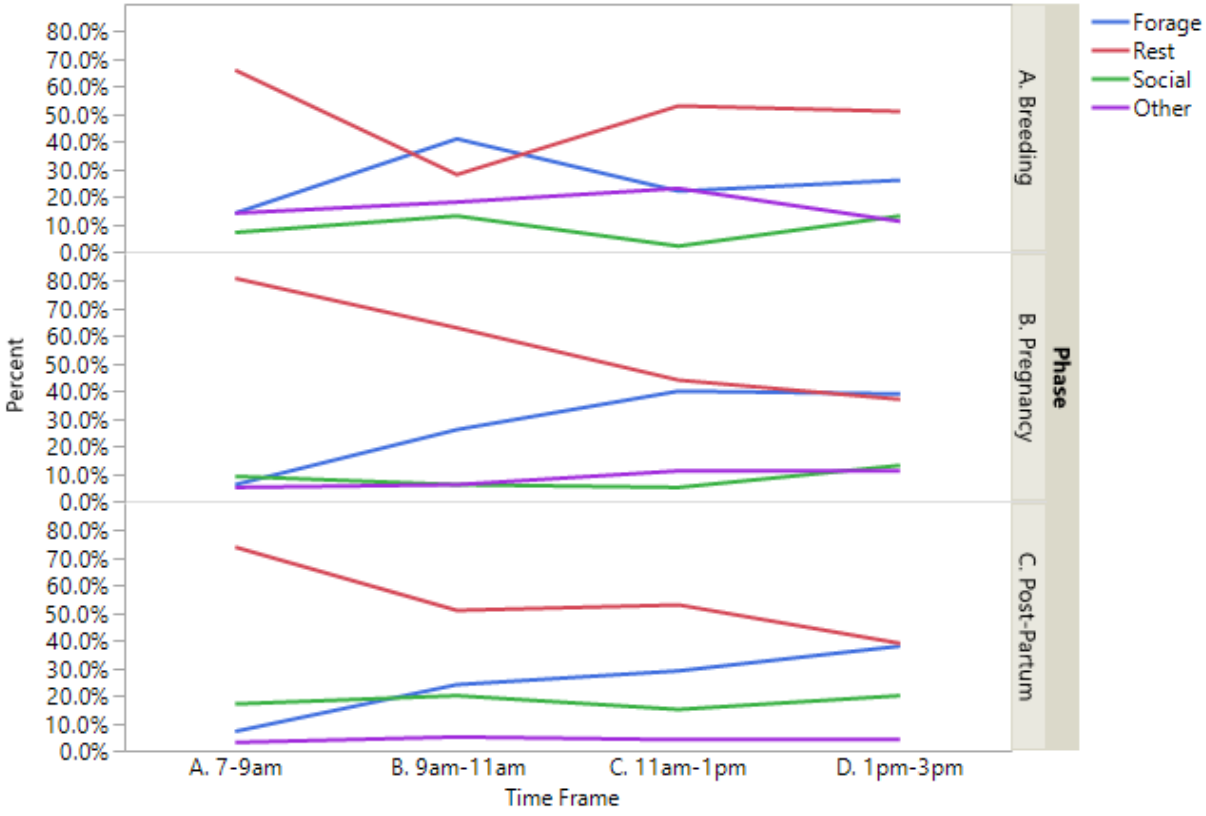

Figure 6. Trends in primary behaviors throughout the day during breeding, pregnancy, and post-partum phases.

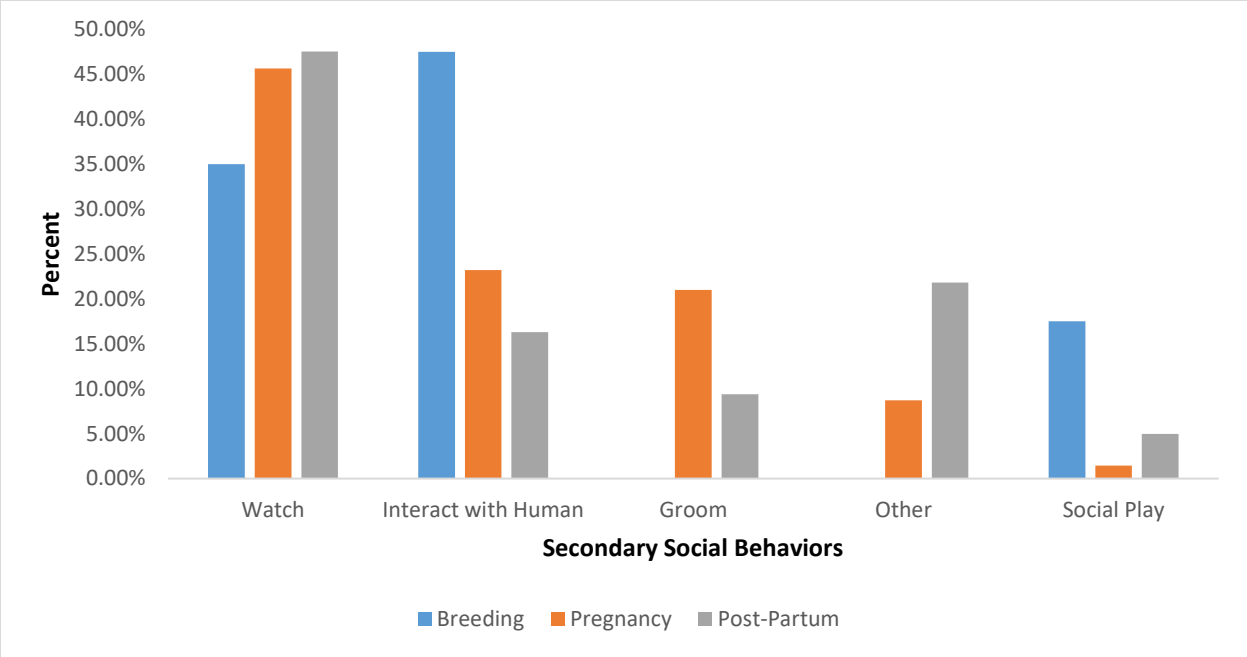

Figure 7. Secondary social behaviors observed during breeding, pregnancy, and post-partum phases.

Nearest Neighbor Analysis

A total of 272 30-minute nearest-neighbor sessions, or 136 hours of observations, were included in social analyses (Table 5). Each nearest orangutan was analyzed based on frequency, representing the number of times that orangutan was recorded within a 30-minute nearest-neighbor session. Iris was Batang's nearest neighbor the most during the breeding phase (29%) (Table 6; Fig. 8). During the pregnancy phase, both Bonnie and Iris were the nearest neighbor but Batang was observed interacting more with Iris during this period. Bonnie was Batang's nearest neighbor during the post-partum phase.

Table 5. Number of focal observations and hours of nearest-neighbor data collection throughout phases of study

Phase	Observations	Hours
Breeding	118	59
Pregnancy	79	39.5
Post-Partum	75	37.5

Table 6. Results of ANOVAs comparing overall nearest-neighbors between phases. *P*-values are significant at <0.05.

Phases	Nearest-Neighbor Overall	*p*-value
Breeding	Iris (29%)	0.0407
Pregnancy	Bonnie (31%) and Iris (31%)	0.1058
Post-Partum	Bonnie (54%)	0.0195

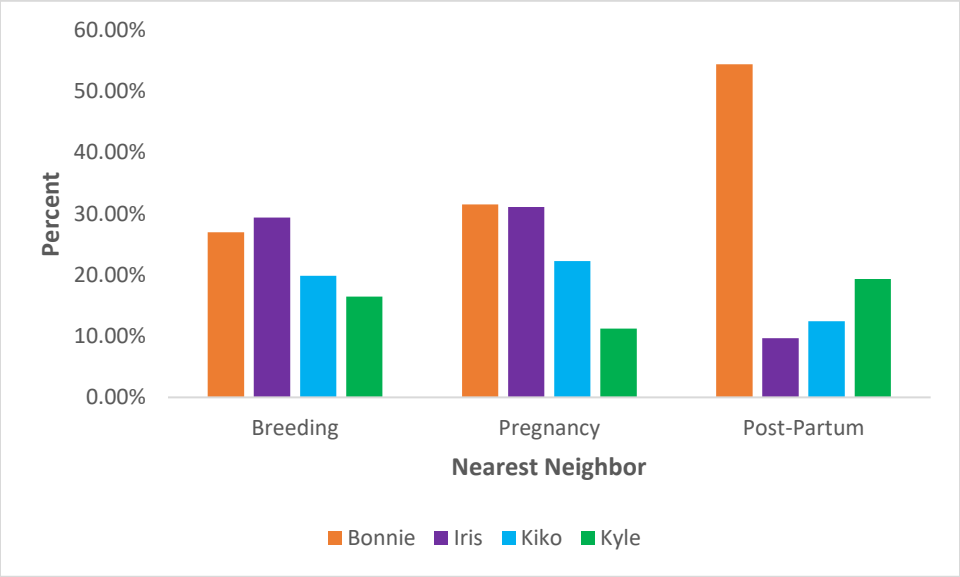

Figure 8. Overall nearest-neighbors observed during breeding, pregnancy, and post-partum phases.

Discussion

Behavior Changes

The goal of the study was to establish a baseline understanding of female orangutan behaviors from reproduction to post-partum. Batang, a 20 year old captive Bornean female orangutan housed at Smithsonian's National Zoo, successfully bred and gave birth to her male offspring, Redd. During this time, she experienced a shift from a playful young adult to an attentive and thoughtful mother. This was made possible as a result of the keepers managing her social network and accommodating husbandry care for her during these different phases.

We are mostly interested in “Forage”/“Social”/“Rest” behaviors because these behaviors are what comprise the majority of captive orangutans’ activity budgets (Sodaro et al., 2006), and changes in the amount of time allocated to these behaviors may influence successful breeding. We hypothesized that behavioral changes during pregnancy would include an increase in resting and decrease in social interactions and foraging. It was found that foraging and social behaviors remained the same while there was an increase in resting (Fig. 5). This is interesting because in terms of foraging, appetite is obviously affected by being pregnant. As recommended by the AZA Orangutan Care Manual, Batang received an adjusted diet for her pregnancy, including prenatal vitamins and Ensure Nutritional Shakes (Sodaro et al., 2006). While foraging behaviors did not increase during the pregnancy phase, Batang still received appropriate nutrients and caloric needs.

Even though there were no significant changes between the baseline breeding phase and pregnancy in terms of primary social behaviors, how and who Batang interacted with (which are secondary behaviors) changed (Fig. 7). During the breeding phase, she interacted with the other adult orangutans, but during the pregnancy phase, she interacted less with the other conspecifics and more with the keepers. This may be influenced by more wellness checks during her pregnancy and an increase in training sessions with the keepers. However, when she did interact with other conspecifics, instead of playful behaviors as during the breeding phase, more time was spent grooming. This may indicate that she was being more conservative in her socialization (i.e., not as energetic).

For the postpartum phase, we hypothesized a decrease in time spent foraging, increase in social behaviors, and increase in resting compared to the baseline. Results showed that Batang decreased in “Forage,” increased in “Social,” and increased in “Rest” compared to the baseline.

For about the first two months of the post-partum phase, the keepers intervened and provided her with food, so she did not need to forage as often. This likely also influenced the amount of time she spent resting, as she did not need to move around as much. The increase in "Social" was for caring for the infant, and not particularly with adults. In line with literature on maternal behaviors, Batang's interactions with Redd revolved around grooming, oral-genital inspection, and manipulation of ano-genital areas (Abelló and Colell, 2006).

Distributions of Primary Behaviors throughout the Day

From breeding to pregnancy we do not see a change in time spent foraging, but when we look at when behaviors are distributed throughout the day, we do see that foraging shifts towards the end of the day. The data collected in accordance with keeper records showed that Batang would rest and would not move out of her nest until later in the morning (Fig. 6). This meant that she was more active in the middle of the day rather than spreading out her activities throughout the day. Keepers did change her feeding schedule in order to accommodate this change in behavior, and this type of flexibility is important in minimizing foraging stress in pregnant primates. In terms of socialization, because Batang was getting up and foraging later in the day, she was also socializing later in the day.

Social Network

During Batang's pregnancy, we expected her to avoid interactions with conspecifics and lose interest in the males. We found that compared to the baseline behaviors, during pregnancy Batang did spend more time alone, spend less time with males, engaged in more conservative behaviors with females (like grooming), and that her nearest neighbor would most often be

female (Fig. 8). During pregnancy, Batang was given more choice about companionship, so instead of being purposefully paired with Bonnie/Kyle, she spent equal time with both pairs and was most often closest to Iris/Kiko. Overall, Batang was in closest proximity to Iris and Bonnie during pregnancy. However, Iris was also the recipient of most of her social behaviors.

In the postpartum phase, we hypothesized that most of Batang's time would be focused on the infant for bonding and learning how to care for it, and less time would be spent with conspecifics, especially the males. The interest from other adult orangutans would influence nearest neighbor data more so than Batang's actual interest in being around other adults. We found that Batang did not have as much choice about her nearest neighbor as she did during pregnancy, because postpartum nearest neighbor was more influenced by the other adult orangutan interest and choice about being near Redd. Bonnie, the experienced mother, was most often nearest neighbor, and Iris, who had been one of nearest neighbor during pregnancy, exhibited avoidance behaviors when in the same space as Batang and the infant. For example, when Batang, carrying Redd, would walk past Iris in a doorway, Iris would try to avoid contact by either backing away or climbing up above mother and child. As expected, the adult males were not invested in paternal care, and kept their distance from Batang and the baby for the most part. They did not exhibit curiosity or try to touch the infant like Bonnie did.

In terms of husbandry, Bonnie was the first adult to be given physical access to Batang because she has had experience raising offspring and she was trained as a surrogate mother. Beyond her role as a potential surrogate mother, it was beneficial to have Bonnie as a babysitter/care giver as Redd got older. Perhaps this lessened the stress on the new mother, and certainly facilitated a more social mother and baby. In a few instances, Bonnie even acted as a protector when Kyle was being aggressive towards Batang. When Kyle would move too close to

Batang, she would make kiss-squeak vocalizations, indicating annoyance or alarm. Bonnie would approach the pair and place herself in between them, as if to diffuse the situation. This behavior was not observed in the breeding or the pregnancy phases. An event like this could indicate that if males are housed with mothers, the group should include females who can interject when males are being aggressive. Having Bonnie as a potential surrogate mother in case of rejection is important but her maternal experience may also be key for new mothers and babies to decrease stress and facilitate appropriate sociality.

Conclusions: Implications of Husbandry and Breeding

Very little data have been collected about how to successfully breed orangutans in captivity. There are surrogacy and hand-rearing protocols, and diet recommendations, but not a consideration of appropriate social groupings and management of maternal choice. In order to improve breeding and rearing success for future breeding Bornean female orangutans, we recommend the AZA's Bornean Orangutan Species Survival Plan® include a more detailed protocol in social management and husbandry adjustments during each stage of reproduction. Here, successful breeding at NZP may be related to quality social grouping, allowing choice by the mother for social pairings. Effectively, Batang, the social butterfly, was allowed to move between pairings, choose her social partners, and manipulate her own social environment. Access to another male may have helped by alleviating stress during the breeding phase. It is assumed females will choose dominant flanged males (Nadler, 1977; Abello et al., 2006), and Batang chose to spend more time with Kiko, who, while sterile, was potentially more dominant than Kyle. If Batang had only one male to interact with, Kyle, and they were not compatible, perhaps the probability of conception would have been greatly affected. Instead, Batang was

given access to both males, copulated with both males, and eventually successfully bred with Kyle. It was clear that she was not choosing to only be around Kyle, regardless of his importance to this process, and it suggests that a diverse and flexible social group is important for the well-being of the breeding mother. It would be beneficial for the breeding protocol to recommend that the breeding female be housed within a group with multiple males or male-female pairs where she can comfortably adjust who she spends her time with.

The keepers followed the AZA Orangutan Husbandry Guide by accommodating Batang's modified feeding and resting schedules. They continued to allow maternal choice about social partners and social environment, including being alone. Batang experienced a healthy pregnancy with no complications during labor and delivery. Batang gave birth to Redd in an enclosure by herself. All other adults were separated from her to provide a less stressful environment for her. Keepers conducted wellness checkups to monitor health and progress of mom and baby for the first four to six weeks. The keepers followed a reintroduction protocol to introduce again the adults back into the social group. First, they gave Batang time to adjust to being a mother, then Bonnie was given access, then Bonnie/Kyle were given access together. The friendly, experienced, protective female Bonnie was also important for these adult reintroductions. Then they allowed Iris to cohabitate, then Iris/Kiko. Because of this process, there was a smooth transition back into the original social groupings that Batang could choose. This study suggests that there are significant differences between behavioral activity budgets of pregnant and postpartum orangutan, and that these needs can be accommodated by allowing as much social choice by the breeding female as possible. Here, Batang was allowed to essentially manipulate her own social environment by having a choice of access to males and other females throughout pregnancy, and those choices supported a healthy and reduced-stress pregnancy and birth.

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APPENDIX A

Timeline of Batang's Life

- December 1996
  - Born at Lincoln Park Zoo, Chicago, Illinois
  - Hand-reared due to death of mother
- July 1997
  - Transferred to Topeka Zoo, Topeka, Kansas
  - Raised by surrogate female orangutan
- October 2004
  - Transferred to Smithsonian's National Zoo, Washington, DC
  - Received SSP® ® breeding recommendation
  - Placed on oral birth control
- July 2014
  - Taken off birth control
- August 2015
  - Began breeding phase data collection
- February 2016
  - Positive pregnancy test and awake sonogram confirm pregnancy
  - Began Pregnancy phase data collection
- September 2016
  - Birth of first offspring, Redd
  - Began Post-Partum phase data collection

APPENDIX B Orangutan Ethogram (Van Schaik, 2015)

Primary behavior	Secondary behavior	Code	Definition
Feed/ forage (F)	Searching, handling, manipulating, or ingesting food items such as primate chow, biscuits, fruits, vegetables, natural vegetation, or food-related enrichment. Includes foraging through bedding or other materials in search of desired food items. (Ross & Lukas, 2002)		
	- cofeeding/ food sharing	Cof/ FS	
	- on fruit	fr	
	- on seeds	sd	
	- on flowers	fl	
	- on insects	ins	
	- on leaves	lv	
	- on vegetation	veg	
	- drink water	w	
	- nurse	D	only for immatures: drink milk from mother
	- other	oth	
Move (M)	Walking, running, crawling, climbing, sliding, jumping, etc. Movements must be greater than one body length/height.		
	- Oline travel order	=>	If an orangutan is on OLine, list orang ID in travel order on Oline of those you can see (e.g. BA, BO, KY = Batang, then Bonnie, then Kyle).
	- brachiate	b	Locomoting by brachiation (swinging arm over arm while body hangs freely underneath)
	cling	c/	only for immatures: being carried clinging to the mother's body, note whether mother supports offspring with arm or leg in item column (Note that Cling is not an exclusive category and may be used in combination with other compatible activities
Nest (N)	Actively constructing a nest (day or night resting location) out of hay or other materials provided; must function as a nest.		
Rest (R)	Inactive/sleep. Individual is not moving and not active in any other behavior listed. Eyes may be open or closed. (Ross & Lukas, 2002)		
	-rest on nest	n	
	- auto explore	Aexp	Investigates non-food-related objects in its environment, including ripping sheets to make wadges, but not simply chewing on them while resting.
	- auto groom	Ag	Picking through hair or at skin of themselves and attempting to remove debris with hands

			and/or mouth. Does not include pulling hair. (Ross & Lukas, 2002)
	- auto play	APO/APM	Following the "play w/ others" definition, this behavior is expressed while an individual is alone and not interacting with any other individuals. The behavior may or may not include objects. Play with self/objects differs from Explore in that this category focuses on behaviors expressed with higher intensity than can be described by the word "investigate".
	- auto sex	Asex	Using a body part, object, or part of the cage to stimulate own genitals. Be sure to separate this from grooming of the genitals or manipulation of the genitals to obtain feces. (Ross & Lukas, 2002)
	- R/R	RR	Regurgitate/Reingest: Bring (swallowed food) up again to the mouth. Ingest again. Take (food or drink) into the body by swallowing or absorbing it.
Social (SOC)	Interactions with other individuals (orangutan or human).		
	- aggression/ display	A/D	Aggressive behavior that includes both contact (physical contact between individuals; includes wrestling, lunge hit, grab, bite, throw and claw) and non-contact (may include pilo-erection and such behaviors as beating on or moving inanimate objects, stomping, slapping, swaying, running, etc.).
	- groom, give	gg	Picking through hair or at skin of another individual and attempting to remove debris with hands and/or mouth. Does not include pulling hair. (Ross & Lukas, 2002)
	- groom, receive	rg	Another individual picking through hair or at skin of the focal animal and attempting to remove debris with hands and/or mouth. Does not include pulling hair. (Ross & Lukas, 2002)
	- interact w/ human	ih	Interaction with staff, volunteers, or visitors behind the scenes and in the public area. Specify if with staff or public.
	- other	oth	Other behavior not listed.

	- play, social	sp	Non-aggressive interactions involving two or more animals. Never accompanied by pilo-erection or agonism. Includes rough-and-tumble play (fast-paced, vigorous locomotion, wrestling, hitting, pulling, chasing, biting, etc.), quiet play (slower-paced, gentle ticklig, finger and toe manipulation, etc.) and also includes social play interaction. (Ross & Lukas, 2002)
	- sexual behavior	sex	Includes mount/copulation, sexual examination, and sexual present (adapted from Ross & Lukas, 2002): Mount/copulation: Includes any component or a series of sexual behaviors including mounting, being mounted, thrusting, being thrust-mounted, and complete copulation. Ventral surface of one animal may be in contact with dorsal surface of another briefly or for extended period. May occur with or without full penetration. Also includes unsuccessful copulations due to incorrect orientation or unreceptive partner. Sexual examination: Visual, oral, or manual inspection of the ano-genital region of another individual or self. This should not be confused with grooming or manipulation of the anus to obtain feces. This includes receiving sexual examination. Sexual present: Animal's posture varies from slight flexion of the arms or turning up the rump toward another to an extreme crouch with all four limbs folder under it, so it is close to the ground. Can occur in response to a solicit from another individual, or without solicitation. Does NOT occur in response to any agonistic behavior.
Out of sight (OOS)		Focal animal not in view of observer.	