

# Gender and Hierarchy Influence Sleep Behavior in Captive Chimpanzees

## Introduction:

Dr. Jane Goodall's visit to the newly opened African Forest section of the Houston Zoo in October 2010 brought instant attention to its newly resident chimpanzees. For me, the event was a like a dream come true. My prior science fair projects on human sleep had shown remarkable correlations between adolescent sleep habits, and their mood, alertness and obesity. I had speculated then about whether similar behaviors were evident in the species genetically closest to humans, particularly gorillas and chimpanzees.

In December 2010, I was given supervised access to the chimpanzee enclosure. When I first entered the chimpanzee habitat, I was confronted by a fearsome din as its residents took the opportunity to vocalize at me, and even throw things in my direction. I knew then that I needed to make observations without disturbing them. Thanks to modern video surveillance technology set up by the zoo, I was able to observe the chimps' daytime activities remotely, and to replay their recorded nocturnal sleeping patterns. The observations made on weekend visits to the zoo over a year have given me an appreciation of the fundamental commonality of the web of life, and given me a deeper insight into the mysteries of sleep in primates.

## Background:

The study of sleep over the last century has made great strides, and there is considerable understanding of the underlying physiological processes. Sleep is not a passive activity. The brain is active during the process of sleeping which is a restorative response affected by multiple environmental factors like light, heat, noise, and the type and location of the sleep site. (Carskadon, 1994, pg. 16).

The quantity and quality of sleep varies during the human life cycle, with discernible changes through development, adulthood and then old age. For example, total sleep in humans decreases with age from 17-18 hours per day in newborns to 7-8 hours per day in adults. Several researchers (Hagenauer et al, 2006) have focused on adolescent changes in the homeostatic and circadian regulation of sleep. Their studies show that delayed timing of sleep in adolescents is due to innate physiological changes attributable to pubertal onset.

The Chimpanzee (*Pan troglodytes*) is modern humans' closest living relative. Knowledge about sleep-related behavior in chimpanzees can provide insights into human sleep behavior, and help us distinguish between intrinsic biologically-based factors, and extrinsic factors like job and societal pressures, chemical and electronic stimulants.

Chimpanzees, unlike other mammals, also share many common characteristics with humans in that they are tool builders, and spend considerable amount of time in creating a comfortable sleep site. (Riss and Goodall, 1976). Their beds

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or 'nests' are the closest equivalents to human beds, and have evolved presumably to allow for increased relaxation and deeper sleep. (Lock, 2011).

Chimpanzee sleeping behavior both in the wild and in captivity has been examined only in a limited fashion (Riis and Goodall, 1976). Videan studied captive chimpanzees and the effect of environmental conditions on their sleep patterns and her work provides several interesting lines of inquiry (Videan, 2006).

### **Purpose and Hypotheses:**

This study made observations of the sleeping habits of chimpanzees without any external interventions. The goal was to develop a sleep behavioral model of chimpanzees factoring in the gender, ages and hierarchical relations, environmental conditions and the intrinsic need to create a sleep haven.

The main hypothesis to be tested was that the hierarchical position of a chimpanzee had an effect on the sleeping location. The second hypothesis to be tested was that quality of bed-making was a function of the sex of the chimpanzees- and that females would be better at that.

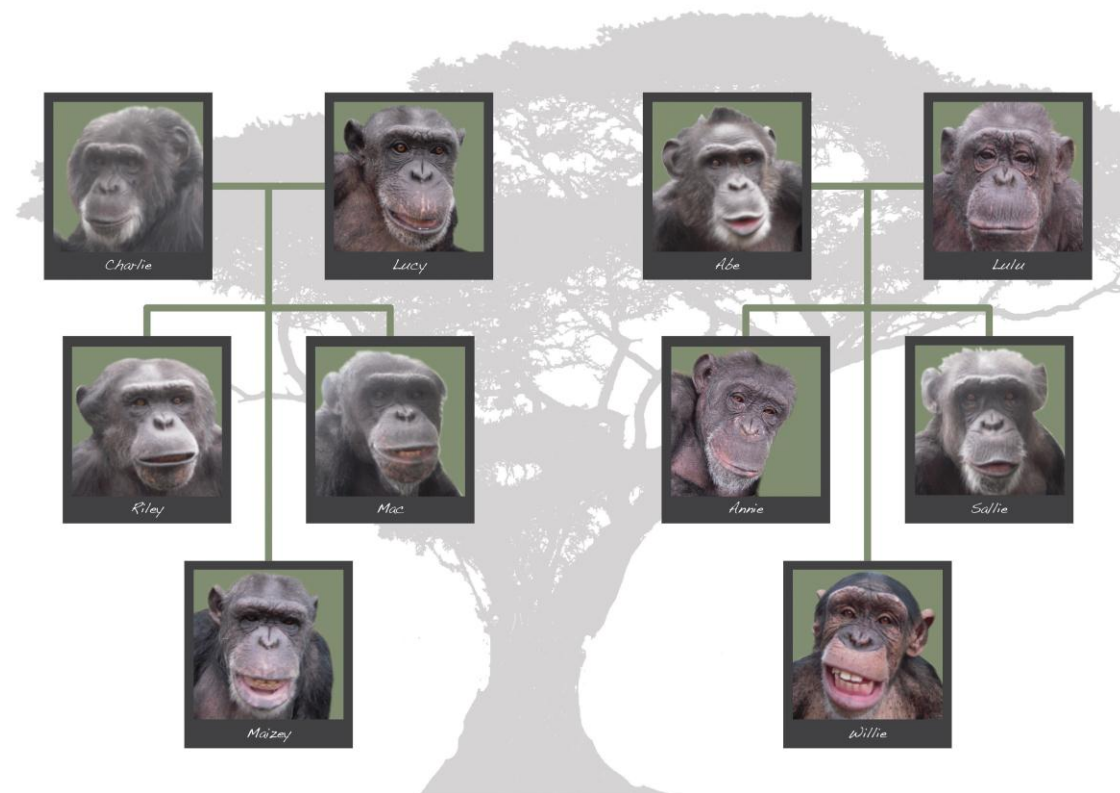
### **Subjects, Site and Methods**

The chimpanzees in this study are housed in a facility in the African Forest section of the Houston Zoo, which was formally opened up to the public for observation in December 2010. The temperature inside the building is maintained at 73° F.

The facility is equipped with multiple low-light sensitive cameras for observational purposes which are tied to a central workstation running SONY RealShot Manager Software for recording and replaying video data. Images are processed, analyzed and archived in real-time enabling observation of the sleep habits in low-light conditions. Nocturnal time-series data is saved for a few days which allows for observations of sleep duration, posture, sleeping partners, and location for each subject. This sleep information was reviewed periodically between December 2010 and January 2012; the observations were captured in a log book, and then transferred for analysis to a Microsoft Excel spreadsheet.

The names and family tree details of the 10 chimps (5 male and 5 female) are shown in Figure 1.

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**Figure 1: Family Tree of Chimpanzees of the Houston Zoo**

The hierarchy within the chimpanzees evolved over the year of observation. Some of the male chimps display in the mornings to show dominance, often coming closer to the exhibit area to interact with each other. At the beginning, the patriarch Charlie was the dominant individual. By the end of the year, the excitable and vocal teenager Mac had supplanted Charlie as the dominant male. Riley, who was often seen grooming Charlie, was lower in the hierarchy. Next was Abe, who liked to put on a big display but without the strength and size to back it up. The youngest and smallest male, Willie, was a naughty troublemaker often disciplined by his elders.

The females did not have as strict a hierarchy. Lucy seemed the most bossy. Lulu was the thinker, who loved watching people. Annie loved to greet people. Sally was the independent one who liked to spend her time alone, but was also Willie's best friend. And Maizey, the largest of the females, loved food. Often the females chose to support each other, even ganging up on a male chimpanzee if necessary.

Six of the chimpanzees in this family tree are children of two females – Lucy and Lulu. Chimps hit puberty around 10 years which lasts till they are 15 years. The

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chimps were divided into three groups - adolescent, prime adult and senior (adult) depending on their ages. The crown-to-rump length and weights of all the chimpanzees were recorded. The total body weight (BW) measured in kilograms and the crown-to-rump length (CR) measured in meters were used to convert to a body mass index (BMI) using formula:  $BMI = (BW/CR^2)$ . (Videan et al, 2007)

Name	Sex	Age Grouping	Age (yrs)	Weight (Kgs)	Crown-Rump (Meters)	Eqvt BMI
Charlie	Male	Senior	39	52	0.79	83
Abe	Male	Senior	39	53	0.77	89
Lulu	Female	Senior	38	68	0.8	106
Lucy	Female	Senior	39	48	0.72	93
Sally	Female	Prime	25	53	0.8	83
Riley	Male	Prime	28	70	0.82	104
Annie	Female	Prime	25	80	0.77	135
Maizey	Female	Prime	26	84	0.74	153
Mac	Male	Prime	18	67	0.84	95
Willie	Male	Adolescent	7	36	0.7	73

**Table 1: Chimpanzee Family Vital Statistics**

### Study of Sleeping Habits

Bed building is an important part of the behavioral repertoire of all wild populations of great apes. Every night each chimpanzee makes a new bed and sleeps in it for about 12 hours. In the wild, nests are almost always in the trees but occasionally they are made on the ground. A young chimp will make nests but will sleep alongside its mother in her nest until she has a new infant. (Riss and Goodall, 1976).

The captive chimpanzees being observed in the Houston Zoo followed similar sleep patterns. Chimpanzees are very circadian by nature. They like to sleep when it becomes dark, which is generally around 5:00 pm during winter months. During the summer months, the chimpanzee trainers would call the chimpanzees inside when it was time for them to eat and go to sleep. All the chimpanzees generally slept inside, but Lulu would occasionally sleep outside, as long as she was covered in the shade.

The intergroup dynamics of the chimpanzee troop played a role in their daytime and nighttime activities. The habitat itself has multiple bedrooms that the chimps can choose to sleep in, or are confined to if they get disruptive. However, the

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majority of them choose to sleep in the Common Room area which has various perches and hammocks set up for them to rest in. (See Figures 2 and 3)



**Figure 2: Top View of the Houston Zoo Chimpanzee Habitat**

All female chimpanzees (except Sally) sometimes used the bedrooms for sleeping. There were many instances of multiple females choosing to sleep in the same bedroom location. Sally on the other hand was a free spirit choosing to sleep in multiple locations in the Common Room but rarely if ever in the bedrooms. Males, for the most part, kept their sleeping areas away from other chimpanzees especially the males. Except Willie, who sometimes slept with his mother Lulu or even the matriarch Lucy, the rest of the males had clearly marked locations they seemed to prefer. Interestingly, it was difficult to identify Riley's sleep location at night, even though during the day he napped publicly in front of the display windows.

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**Figure 3: Front View of Common Room with locations identified with letters**

(A,B,C,D,E,F,G: Pole Perches of Increasing height, H:Right Pole Perch, I: Left Pole Perch, J: Hammock between L and M, K: Hammock between B and wall, L and M: Back Wall Perches, N: Tunnel in back, O: Floor & benches)

My theory was that chimpanzees in the wild slept at elevated heights to protect themselves from predators and from other higher status chimps. To test my hypothesis that chimpanzees' hierarchical positions affected the sleeping locations, I recorded locations where they slept in the Common Room on most nights. To analyze the relative heights of the perches, they were assigned scores based on an assessment of the relative security they seemed to offer the chimpanzee. In this scoring system, the locations labeled O (floor and benches there) were given a score of 0 because they offer the least security. Common areas like the tunnel were assigned a weight of 1. The vertical perches were given increasing scores depending on their height how. The locations and the corresponding scores assigned are shown in rows 2 and 3 of Table 2 which shows the relative male and female hierarchy as well as the preferred sleep locations for individual chimpanzees identified with an "x".



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The score average in each row is a metric of the relative security of the sleeping sites for a particular chimpanzee. For example, Annie was observed to sleep at locations D, G, H, L and M with corresponding scores of 7, 10, 3, 6 and 1. The average of these numbers was  $27/5=5.4$ .

	Hierarchy	Dayroom Locations (with scores)															Average Score	Bedrooms
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O		
		1	2	4	7	8	9	10	3	3	6	2	6	6	1	0		
Charlie	1														x	x	0.5	
Mac	2	x	x														1.5	
Riley	3																	
Abe	4				x	x											7.5	
Willie	5			x				x									7	
Lucy	1													x	x		3.5	x
Lulu	2			x								x					3	x
Sally	3							x		x		x	x				4.25	
Annie	4				x			x	x					x	x		5.4	x
Maizey	5					x	x							x			7.7	x

**Table 2: Hierarchy and relative sleeping locations of chimpanzee troop**

It takes 5-10 minutes at most for a chimpanzee to make a comfortable bed. Given the choice of grass, hay, wood-wool, cardboard, newspapers, and blankets, the chimpanzees chose to nest-build with their particular preferences for materials. Annie and Sally were partial to blankets. In fact most of the chimps were fond of their blankets and could be seen carrying them around on their backs, or napping with them in the hammocks. Additionally, Sally would retire to a hammock with hay and newspapers. Abe, Willie, and Lucy liked hay.

Charlie, like other males, preferred to spend the night time away from other males. Willie, the youngest of the group, was a fairly restless sleeper, rocking himself in his sleep and moving extensively through the night.

The most elaborate beds were made by Maizey. Other than Sally, the other females had a congenial relationship with each other, and were more likely to share some of the 8 bedrooms. One interesting observation I made was that Annie was not a very keen nest builder, contrary to most of the other females in the group. If possible, Annie liked to sleep in already made beds, in addition to wrapping herself in blankets.

The females in general tended to make more elaborate beds than the males, and also tended to spend more time making their beds which confirmed the secondary hypothesis.

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**Figure 4: Sally with blanket and hay**



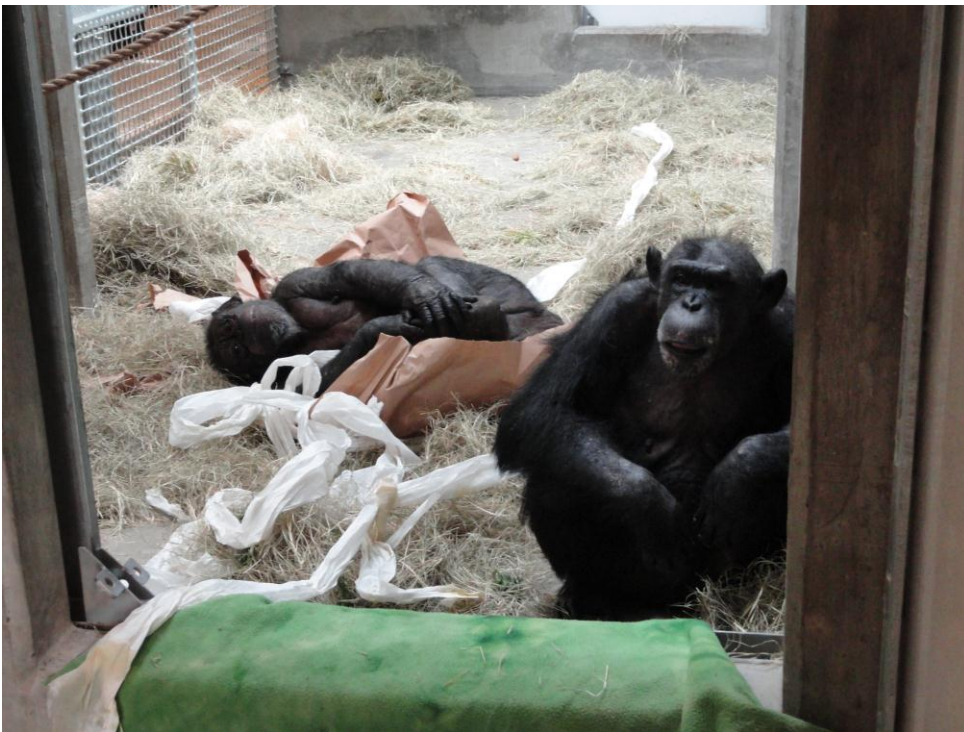
**Figure 5: Sally in Hammock**



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**Figure 6: Annie in Hammock**



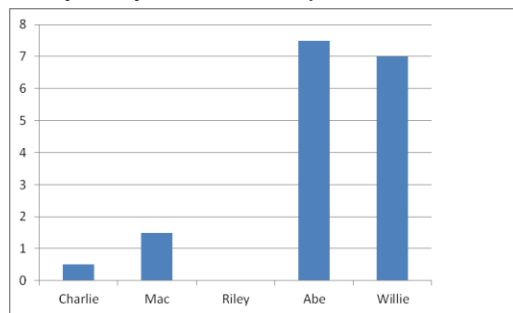
**Figure 7: Lucy and Lulu in one of the bedrooms**

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### Data Analysis

Sleep retirement duration was  $12:32 \pm 25$  mins and the average sleep duration was  $9:46 \pm 25$ . The senior chimpanzees had longer sleep durations than prime and adolescent chimps despite retiring for sleep and rousing at the same time.

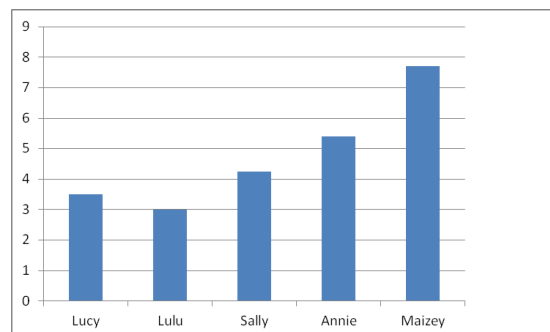
Table 2 indicates that higher the dominance of a male chimpanzee the more likely they are to sleep at a lower or more vulnerable location. Even with the



limited sample size, the more dominant males are likely to occupy the lower locations for night beds. The younger or more vulnerable the male, the more likely that they occupy the higher perches. Thus Charlie and Mac, the two most dominant males, though occupying mutually exclusive spaces nevertheless slept closer to the ground.

**Figure 8: Male Chimp Sleep Location Trend**

Females too show a similar trend. Most of the female chimps felt comfortable in sleeping on the ground level of the bedrooms, which would be quite rare in the wild. This may be due to the lack of predation and sense of security in a captive setting. There also is more communality and sharing of resources among the females.



**Figure 9: Female Chimp Sleep Location Trend**

### Discussion

It was hard to quantify the actual sleep durations for individual chimpanzees. Typically older chimpanzees slept longer and had fewer and shorter nighttime awakenings than prime adult chimpanzees. This may be consistent with human studies, where it is reported that older humans sleep less and experience greater nighttime awakenings. (Carskadon, et al) The differences observed in nest building between the two sexes support the hypothesis that females have greater manipulative ability than males and have greater proficiency in bed building.

### Further Research

Further research using non-invasive nighttime recording equipment could identify instances of wakefulness, postural change and copulatory activities, and help in scoring sleep stages. Also, it would be interesting to study the circadian sleep behavior of adolescent chimpanzees with relation to the adults.

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