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Testing the weekend effect hypothesis: time of day and lunar phase better predict the timing of births in laboratory-housed primates than day of week

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Abstract

The weekend effect hypothesis proposes that captive primates are more likely to give birth during times of low disturbance and reduced staff activity. The hypothesis specifically predicts that laboratory-housed primates will be more likely to give birth during the weekend than weekdays when staff activity is reduced. To date, support for the weekend effect hypothesis has been mixed and based on studies with relatively few subjects. To further examine the hypothesis, we analyzed the birthing patterns of three genera of laboratory-housed primates: squirrel monkeys (*Saimiri* species, N=2090 births), owl monkeys (*Aotus* species, N=479 births), and rhesus macaques (*Macaca mulatta*, N=2047 births). Contrary to predictions derived from the weekend effect hypothesis, the frequencies of births during weekends for all taxa were not significantly different from rates that would be expected by chance. However, while there was not variance across days of the week, all three taxa gave birth at nighttime, when staff were absent. This parallels reports of births in wild and captive monkeys, both diurnal and nocturnal, which are more likely to give birth during the night; plausibly a time when environmental and social disturbance is lowest and the mother is safest to bond with her newborn infant. As all births occurred at night, we also explored the relationship between the lunar cycle and timing of births timing. While the diurnal primates (i.e. *Saimiri* and *Macaca*) were no more likely to give birth on “bright” nights than “dark” nights, owl monkeys (*Aotus*) had a much higher frequency of births on bright nights than darker ones, and at rates that deviated from chance. Our data provide a more detailed understanding on how the environment may influence captive monkey births, but do not support the oft-cited weekend effect hypothesis.

Graphical Abstract

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Keywords

weekend effect; birth; parturition; old world monkey; new world monkey; lunar cycle

Introduction

The periodicity of births among primates varies with time of year (Di Bitetti & Janson, 2000), the day of the week (McGrew & McLuckie, 1984), and even by the hour of the day (Goodlin & Sackett, 1983; Jolly, 1972). Environmental factors, including rainfall (Vandenbergh & Vessey, 1968) and moon cycle (Cowgill, Bishop, Andrew, & Hutchinson, 1961), have also been shown to correlate with the timing of estrous and mate choice. These environmental factors likely influence the relative abundance of foods (Fernandez-Duque, Rotundo, Ramirez-Llorens, & 2002), which correlates with primate mating and birthing patterns (Takahashi, 2002), and light intensity, which is known to influence the animals' general activity (Cowgill et al., 1961; Fernandez-Duque & Erkert, 2006).

When considering captive nonhuman primates, however, much of their environment is tightly controlled. These primates may not experience some of the environmental cues that trigger species-typical breeding and birthing patterns observed among wild populations (e.g., seasonal breeding, Bicca-Marques & Gomes, 2005), but they may be exposed to a different set of external factors that influence their activity. For example, in a captive setting the presence of human caretakers, veterinarians, and researchers may have an influence on primates' behavior (Lambeth, Bloomsmith, & Alford, 1997; Barbosa & da Silva Mota, 2009; Chelluri, Ross, & Wagner, 2013), including the time when they give birth (McGrew &

McLuckie, 1984; Alford et al., 1992). Specifically, it has been proposed that, in captivity, primates may be more likely to give birth during the weekend, a time of reduced disturbance from animal care staff, than during the week (Morton & Swindler, 2005).

The weekend effect hypothesis was first described by McGrew and McLuckie (1984). In their report, McGrew and McLuckie showed that laboratory-housed Callitrichidae (*Callithrix j. jacchus* and *Saguinus o. oedipus*) were more likely to give birth at weekends than on weekdays. In a similar study, Alford et al. (1992) showed that captive chimpanzees (*Pan troglodytes*) in a laboratory setting were more likely to give birth on Sundays and Mondays; the authors attributed this pattern to a carry-over effect from reduced staff disturbance on Saturdays and Sundays, the days immediately prior to the birthdays. To evaluate the robustness of their findings, McGrew and McLuckie (1984) expanded their evaluation to include Callitrichidae housed at a second research facility. Contrary to their initial findings, however, the weekend effect at the second facility was smaller and did not reach statistical significance, despite the much larger number of births considered in this new data set. It remains unclear whether this cross-facility difference could be due to idiosyncratic characteristics of the first facility or an artifact of sampling. Additional studies with both apes (*Gorilla gorilla gorilla*, Kurtycz & Ross, 2015; *P. troglodytes*, Wagner & Ross, 2008) and monkeys (*Macaca nemestrina*, Goodlin & Sackett, 1983; *M. arctoides*, McGrew & McLuckie, 1984) also reported no evidence for a weekend effect, calling this previously-identified phenomenon into question.

The weekend effect hypothesis has also been evaluated with data from zoo-housed primates. Contrary to laboratory-housed primates, whose birthing patterns may be influenced by fewer staff working during weekends, it has been proposed that zoo-housed primates may be under greater stress at weekends, when the number of visitors increases (Hosey, 2005). In other words, a more general formulation of the weekend effect hypothesis would state that it is not any specific day of the week that predicts the timing of birth, but rather, changes in human activity levels. An examination of the hypothesis based on chimpanzee births in zoos accredited by the Association of Zoos and Aquariums found that births were no more likely during weekdays than weekends (Wagner & Ross, 2008), and a similar finding was reported more recently for zoo-housed gorillas (Kurtycz & Ross, 2015).

Not only have recent studies failed to find definite evidence in support of the weekend hypothesis proposed by McGrew and McLuckie (1984), but the number of births considered in most early studies was limited (e.g., McGrew & McLuckie, 1984, N = 24 Callitrichidae births, and N = 95 *M. arctoides* births). Interestingly, the two studies of zoo-housed apes, which did not find much variance across the week for numbers of births per day, included considerably more births in their analyses (Wagner & Ross, 2008, N = 231 chimpanzee births; Kurtycz & Ross, 2015, N = 336 gorilla births). A more robust evaluation of the hypothesis would benefit from an evaluation that includes numerous taxa, numerous births, and a long time frame.

Our first aim was to quantify the relationship between the timing of births and the day of the week to examine the robustness of the weekend effect hypothesis. To address this, we conducted a multi-species assessment of the weekend effect hypothesis using (i) three

primate genera that had not previously been assessed, (ii) a large number of births (>400 births per genera) and (iii) data gathered during multiple years (>12 years of data for each genera). Specifically, we analyzed the birth rates from breeding colonies of squirrel monkeys (*Saimiri* species, N = 2090 live births), owl monkeys (*Aotus* species, N = 479 live births), and rhesus macaques (*M. mulatta*, N = 2047 births) housed in a laboratory setting. While the seasonal breeding patterns of wild and captive *Saimiri* sp., *Aotus* sp., and *M. mulatta* have been documented (Jack, 2010; Fernandez-Duque, 2011; Kubisch, Falkenstein, Deroche, & Franke, 2012; Silk, Short, Roberts, & Kusnitz, 1993; Williams, Brady, Gibson, & Abee, 1994), less is known about fluctuations in the timing of births in response to environmental stressors (e.g., Rudran & Fernandez-Duque, 2003) and the potential impact of staff activity on the birthing patterns of captive *Saimiri* sp., *Aotus* sp., and *M. mulatta* has not previously been explored.

As all the primates that we studied had access to natural light cycles, because their enclosures included outdoor areas or through louvers in the ceiling of their colony room, we were also able to examine the lunar cycle as another environmental factor that may influence the timing of births. Numerous studies have explored the potential link between the lunar cycle and human births, with some finding a relationship (e.g., Menaker, 1967; Guillon et al., 1986; Criss & Marcum, 2010) and others not (e.g., Abell & Greenspan, 1979; Waldoer, Haidinger & Vutuc, 2002; Arliss, Kaplan, & Galvin, 2005; Kuss & Kuehn, 2008). While moon phase has been shown to influence the activity of certain primate species (e.g., Fernandez-Duque & Erkert, 2006), whether the phase of the lunar cycle influences the timing of primates' births has not been explored. This was our second aim.

Thus, our study aimed to investigate the relationships between two environmental factors and the temporality of captive primates' birthing patterns: staff activity (i.e. the purported weekend effect) and the lunar cycle. At the facility where our study subjects were housed, more care technicians, veterinary staff and researchers were present in animal areas during weekdays than on weekends. Furthermore, the care technicians worked longer shifts during weekdays than weekend days. Given these changes in personnel routine and activity during the week, for our first aim we predicted that, if there is a true weekend effect, there should be a greater number of live births recorded during weekend days than week days due to the reduction in disturbances on Saturdays and Sundays. For our second aim, given that primates, and especially nocturnal ones, are more active during full-moon nights (e.g., Erkert, 2008; Fernandez-Duque & Erkert, 2006), and captive primates are more likely to give birth at night (Price, Payne, & Wormell, 2016), we predicted that the monkeys, especially the owl monkeys, would be more likely to give birth when there was increased night light.

Methods

Subjects and Housing

The Squirrel Monkey Breeding and Research Resource (SMBRR) and the Owl Monkey Breeding and Research Resource (OMBRR) are established breeding colonies whose purpose has been the study of the biology and behavior of reproduction in these two genera. Both colonies were originally established at the University of South Alabama (UoSA); the

SMBRR in 1981 and the OMBRR 2001. In January and February of 2008 both colonies were relocated from the UoSA in Mobile, Alabama to Bastrop, Texas to become part of the Michale E. Keeling Center for Comparative Medicine and Research (KCCMR) at the UT MD Anderson Cancer Center. The Rhesus colony has been maintained at KCCMR since 1976 as part of a specific pathogen-free (SPF) colony derived at the KCCMR.

While housed at the UoSA, the squirrel monkey colony was housed in indoor/outdoor enclosures (w 1.2m × h 2m × d 4.5m) with breeding groups of 20–25 animals comprised of one male for every 10–15 females. All housing had heating and cooling, and access to natural lighting. In addition, supplemental indoor lighting was controlled by a timer that tracked the natural sunrise/sunset for Mobile's latitude. After the move to the KCCMR in Texas, the squirrel monkeys were housed in similarly-sized groups and cages, but were maintained exclusively indoors. Furthermore, two changes were made to the lighting. The animals still had access to natural light through overhead louvers, but the interior lighting was set to a 12/12 light/dark schedule (07:00 to 19:00 light). When housed at the UoSA, the squirrel monkeys experienced shorter daylight hours during the winter months and longer daylight hours in the summer, while at KCCMR the monkeys had long days in the summer, but the interior lights extended the lighted time in the winter past the natural sunset.

Owl monkeys at the UoSA were housed as mated pairs with one to three offspring in 1.2m × 1.2m × 1.7m cages. The owl monkey enclosures at the UoSA were in standard laboratory housing rooms, with central heating and cooling. The light cycle was set to a 12/12 light/dark schedule (03:00–15:00 lights on). After the move to the KCCMR, the lighting schedule was shifted to 00:00–12:00 lights on, with low levels of natural sunlight available through overhead louvers from 12:00 to 15:00 to simulate a twilight period, but all other housing conditions remained the same (e.g., cage size). For both genera the staffing protocols at both UoSA and KCCMR were the same.

The rhesus macaques at KCCMR were housed in rectangular pens (2.7m × 3m × 3.5m) with one wall open to an interior corridor, two solid side walls, and one wall open to outside. Each group was exposed to natural sunrise and sunset. Groups consisted of one adult male and 6–10 adult females. Offspring were weaned when they were approximately seven months of age and then moved to age-peer groups.

All three genera were provided with food and non-food environmental enrichment devices daily, as part of a robust behavioral management program at KCCMR. Enrichment devices, which were changed every two weeks at minimum, were hung throughout the cage and were designed to encourage manipulation and exploration. Additionally, all enclosures included perches and climbing structures to encourage three-dimensional use of the cage, and each of the *Aotus* cages provided limited visual access to neighboring pairs and groups to reduce aggression associated.

Husbandry Procedures

Husbandry procedures for the three genera were similar during the study period. On week days, Monday through Friday, there were approximately 6–10 technical and research personnel present from 07:00 to 17:00 h. There was an early morning clinical observation of

all the animals, followed by cage cleaning, and the main feeding of the day; all of which were usually completed between 10:00 and 11:00 h. Cages and runs were sanitized on a bi-weekly schedule with some cages being sanitized each day. Clinical treatment of the animals was conducted throughout the day on weekdays. Clinical treatments included observations by staff, manual capture for medications and sample collection, and short term removal to a procedure room when treatment required. There were also times when animals were housed away from their social groups for periods of several weeks if veterinary care was prescribed. During late afternoon, the animals were fed again and a second clinical observation was made of all of them. Very little work was scheduled for weekends; all major mechanical and physical plant work was only done during weekday hours. On the weekends, typically only one or two technical staff were present, moving quickly through the colonies to clean and feed the animals, and to perform any necessary clinical treatments. Weekend days were typically shorter, 07:00 to 16:00 h, quieter, and the monkeys were seldom disrupted.

Data Analysis

We used 4,616 live births in the analyses. All rhesus macaque births analyzed occurred at KCCMR, while the squirrel and owl monkey births occurred at both UoSA and the KCCMR. While we included data for the squirrel monkeys from UoSA and KCCMR, statistical analyses showed no statistically significant differences in the number of births by days of the week between the birth frequencies at UoSA and KCCMR ($X^2=1.56, df=6, P>0.05$) so the data were combined for testing. The data analyzed consisted of all unassisted births recorded for the squirrel monkey colony between 1982–2014, for the owl monkey colony between 2002–2014 and for the rhesus macaque colony between 1977–2014. All births occurred during the night period (i.e. after staff had left for the day) with infants first identified the next morning.

In the wild, seasonal breeding patterns have been suggested to be influenced by environmental factors, such as day-length, temperature, rainfall, and food abundance (Baldwin, 1985; Trevino, 2007; Jack, 2010). Like their wild counterparts, the squirrel monkeys and rhesus macaques included in this study also showed seasonal breeding patterns (Wiebe, Williams, Abee, Yeoman, & Diamond, 1988; Williams, Brady, & Abee 2010). The owl monkeys in the colony did not show seasonal breeding patterns, unlike what has been reported for at least one wild population (Fernandez-Duque, 2011). Given that the evidence of seasonality in other captive colonies of owl monkeys is mixed (Dixon, 1983; Gozalo & Montoya, 1990) birthing information for owl monkeys was included from throughout the year. While births by the macaques and squirrel monkeys outside of breeding season were incredibly rare (often attributed to group formations or other social manipulations), we did not exclude these data from analyses.

In order to investigate the potential association between patterns of activity and birth rates, the week was divided into those days with normal human activity levels (i.e. weekdays) and those with reduced staff and research activity (i.e. weekends). Since all of our recorded live births occurred “over night” (during the dark period for the two diurnal genera and during the light period for the nocturnal genus), we assigned deliveries recorded one day to the possible influence of human activity on the previous day (i.e. births observed on Sunday

morning would have occurred on Saturday night). We used a log likelihood goodness of fit (G-test) statistic to compare the observed frequencies of birth events to the expected frequencies (i.e. 14.3% of births on each day of the week) across the seven days of the week, with such analysis run for each genera. We also used a log likelihood goodness of fit (G-test) statistic to compare the observed frequencies of births on weekends *versus* weekdays to expected frequencies (i.e. 71.4% of births on weekdays and 28.6% on weekends). Since all births occurred overnight, our hypothesis was that activity on the prior day influences deliveries. Therefore, “weekday” births were summarized as Tuesday through Saturday mornings, and weekend deliveries as Sunday and Monday mornings (see Table 1).

We calculated moon phases with a synodic period (lunar cycle length) of 29.54 days, using 07 January 1970 as a reference point for a new moon (<http://aa.usno.navy.mil/>). We categorized the lunar cycle as eight phases (new moon through waning crescent). In order to compare relatively bright nights with relatively dark ones, we combined the days when the moon was full, waxing gibbous and waning gibbous (“bright nights”) and compared it to a combination of days when the moon was new, waxing crescent and waning crescent (“dark nights”) (see Table 2). In order to compare the frequencies of births occurring during “bright” and “dark” nights, births occurring on nights with full or gibbous moons were pooled for “bright” nights and those during new or crescent moons were pooled for “dark” nights. We compared observed frequencies to expected ones (i.e. that there would be an equal likelihood of births occurring on “bright” or “dark” nights).

We ran all analyses in R version 3.5.2 (R Core Team, 2018) using the GTest function in the DescTools package (Signorell, 2019).

Results

The distribution of live births across days of the week was relatively even for all three taxa; the percentage of births on each day varied between 13% and 16% (Table 1). The variation did not reach statistical significance for any of the taxa: *Aotus* ($G = 3.49$, $df = 6$, $P = 0.745$), *Macaca* ($G = 2.03$, $df = 6$, $P = 0.917$), and *Saimiri* ($G = 6.92$, $df = 6$, $P = 0.328$). When considering the likelihood of births occurring on weekdays compared to weekend days, again, the three taxa did not show differences in their birthing patterns that reached statistical significance: *Aotus* ($G = 0.04$, $df = 1$, $P = 0.840$), *Macaca* ($G = 1.11$, $df = 1$, $P = 0.293$), and *Saimiri* ($G = 1.38$, $df = 1$, $P = 0.240$) (Table 1).

The distribution of the macaques’ and squirrel monkeys’ births across the eight different lunar phases was relatively even (Table 2), and no statistically significant differences in the timing of their births across phases were detected: *Macaca* ($G = 9.60$, $df = 7$, $P = 0.212$) and *Saimiri* ($G = 7.11$, $df = 7$, $P = 0.417$). There was also a lack of any substantial difference between the number of macaque or squirrel monkey births that occurred on “dark” *versus* “bright” nights: *Macaca* ($G = 0.124$, $df = 1$, $P = 0.725$) and *Saimiri* ($G = 0.105$, $df = 1$, $P = 0.746$) (Table 2). In contrast, the owl monkeys showed more variation in the timing of their births, with only 9% of births occurring in the new moon phase but 16% during the waxing gibbous phase (comparing the frequency of *Aotus* births across the eight different lunar phases: $G = 13.95$, $df = 7$, $P = 0.052$). In these nocturnal primates, the number of births

occurring during the three “brighter” moon phases was substantially larger than during the “darker” phases and statistically significant (Table 2, $G = 6.94$, $df = 1$, $P = 0.008$).

Discussion

Our aim was to examine the weekend effect hypothesis, which proposes that captive primates are more likely to give birth during times of low disturbance and reduced staff activity (i.e. at weekends in laboratories, McGrew & Luckie, 1984). Contrary to the predictions of the hypothesis, the three monkey genera we studied showed extremely little variation in their birthing patterns across weekdays and weekends compared. This provides further support for previous studies that have also challenged the weekend effect hypothesis and reported no strong effect of day-of-week on parturition rates (Goodlin & Sackett, 1983; McGrew & McLuckie, 1984; Wagner & Ross, 2008; Kurtycz & Ross, 2015).

Not only was there no substantial variation throughout the week in the monkeys' pattern of births, there was also no noticeable variation across the three genera in terms of the time of day that they gave birth: all the births occurred over night, not during the day time. This parallels the behavior reported for many diurnal primates, which have been shown to give birth more frequently at nighttime than during the day (Bowden, Winter, & Ploog 1967; Joly, 1973; Solanki & Zothansiana, 2013; Price et al., 2016). However, and following our prediction, the nocturnal owl monkeys were more likely to give birth on bright nights. Thus, all three genera gave birth at night time (i.e. when staff were absent) and for the nocturnal genera their birth rates were further influenced by the lunar cycle.

Thus, in our study, all births occurred, not when staff activity was *lower*, as predicted by the weekend effect hypothesis, but when staff activity was at its *lowest* (i.e. at night, when no staff were present). Honnebier and Nathanielsz (1994) proposed that “natural selection has favored mechanisms that couple the time of birth to the most appropriate phase of the daily cycle of light and darkness...birth normally occurs during the hours when the animal rests or sleeps. In a natural environment, this enables mother and newborn to take advantage of their shelter so that the critical first postpartum hours of neonatal adaptation, maternal bonding and postnatal development can be spent in peace and quiet without interference of disturbing and dangerous influences inherent to their habitat” (p. 193–194). This suggests that nighttime birthing patterns are not only favorable for diurnal monkeys in “a natural environment” (*sensu* Honnebier & Nathanielsz, 1994), but also for animals in a captive setting. Indeed, a recent review of callitrichid births in a zoo setting revealed that seven of the eight species studied preferentially gave birth during night time (the exception was *Saguinus bicolor*, Price et al., 2016).

The nocturnal owl monkeys, like the diurnal monkeys, also only gave birth when staff were absent (i.e. at our night). For owl monkeys, nighttime is the period when they are most active (Fernandez-Duque, 2003). Furthermore, data on wild owl monkey (*A. azarae*) births from the Owl Monkey Project site in Formosa, Argentina, suggest that, like the captive monkeys at KCCMR, this species is more likely to give birth at nighttime like diurnal primates (E. Fernandez-Duque, unpublished data). We note, however, that for the nocturnal owl monkeys at KCCMR, their nighttime was artificially shifted such that the period when staff were not

present (17:00–07:00 on weekdays and 16:00–07:00 on weekends) included both a dark period (16:00 – 00:00) and a light period (00:00 to 07:00). On nights with a full or gibbous moon, therefore, even the dark period would have been less dark. More work investigating the interplay between light availability (whether natural or artificial) and primates' activity (especially nocturnal species housed on a shifted cycle) is needed (see e.g., Sulzman, Fuller, & Moore-Ede, 1979; Fuller, Kuhar, Dennis, & Lukas, 2012).

Our study suggests that birth timing (day of week) is likely not a reliable proxy for measuring captive primates' stress. Direct measures of primates' physiological stress markers (e.g., glucocorticoids, Novak et al., 2017) or mood (e.g., Bethell, Holmes, MacLarnon & Semple, 2016; Cronin et al., 2018), would likely provide more direct information about captive primates' wellbeing. Additionally, to provide a more detailed understanding of the timing of captive primates' births, and how environmental stressors may impact these patterns, we encourage further research both to objectively measure changes in environmental stressors (e.g., noise levels on weekdays, weekend days, and nighttime periods, e.g., Wark, 2015) and in the monkeys' stress levels. Specifically, it would be useful to record whether there were changes in the monkeys' behavior and physiological state throughout the 24 h cycle and over the course of the week. This would reveal whether staff activity levels are correlated with rates of behavioral indicators of stress (e.g., stereotypical or self-injurious behavior, Schneider, 1992) or cortisol levels (Hanson, Larson, Snowden, 1976). Although environmental stress was not reported to increase the likelihood of aborted or premature births for laboratory-housed rhesus macaques (Schneider, 1992), more data are required to tease apart the link between fluctuations in environmental stressors and birthing patterns.

We conclude that time of day may be a more important predictor of parturition than day of week, and therefore the weekend effect hypothesis is likely not a useful rubric for understanding captive primate stress. However, and in agreement with data from both wild and captive primates, we did find that the monkeys were more likely to give birth at night, than during the day. We also found that the nocturnal owl monkeys were more likely to give birth on bright, not dark, nighttime periods. Unfortunately, we were not able to record the time of day when births occur, whether it was simply periods when staff were absent or specifically at nighttime/dark periods (especially pertinent for owl monkeys) and future work should aim to explore this. For managers of captive primates, whether breeding primates for research (e.g., the Squirrel Monkey Breeding and Research Resource) or as part of the Species Survival Plans® managed through the Association of Zoos and Aquariums, more data are required to determine how the very people who care for these animals, may influence their breeding patterns, if at all.

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Research Highlights

- For captive primates, time of day may be a more important predictor of parturition than day of week.
- "Counter to the weekend effect hypothesis, for *Aotus*, *Macaca*, and *Saimiri*, birth timing was not influenced by day of week
- "For nocturnal *Aotus*, lunar phase correlated with birth timing

Table 1.

Number and percentage of live births in owl monkeys (*Aotus*), rhesus macaques (*Macaca*) and squirrel monkeys (*Saimiri*) across the seven days of the week and comparing weekdays (i.e. births reported on the mornings of Tuesday + Wednesday + Thursday + Friday + Saturday) with weekends (i.e. births reported on the mornings of Sunday + Monday).

		Genera					
		<i>Aotus</i>		<i>Macaca</i>		<i>Saimiri</i>	
		Number	%	Number	%	Number	%
Day of the Week	Monday	66	14	269	13	302	14
	Tuesday	77	16	297	15	289	14
	Wednesday	64	13	288	14	312	15
	Thursday	77	16	284	14	344	16
	Friday	60	13	326	16	288	14
	Saturday	62	13	288	14	282	13
	Sunday	73	15	295	14	273	13
Weekdays		340	72	1483	72	1515	72
Weekend		139	28	564	28	575	28
Total		479		2047		2090	

Table 2.

Distribution of births in owl monkeys (*Aotus*), rhesus macaques (*Macaca*), and squirrel monkeys (*Saimiri*) across the eight lunar phases as well as our categorization of “dark” (waning crescent + new moon + waxing crescent) and “bright” nights (waxing gibbous + full moon + waning gibbous).

		Genera					
		<i>Aotus</i>		<i>Macaca</i>		<i>Saimiri</i>	
		Number	%	Number	%	Number	%
Moon Phases	New moon	42	9	265	13	268	13
	Waxing crescent	51	11	254	12	268	13
	First quarter	69	14	227	11	243	12
	Waxing gibbous	76	16	273	13	277	13
	Full moon	56	12	264	13	259	12
	Waning gibbous	66	14	249	12	278	13
	Last quarter	63	13	234	11	232	11
	Waning crescent	56	12	281	14	265	13
“Dark” Nights		149	31	800	39	801	38
“Bright” Nights		198	41	786	38	814	39
Total		479		2047		2090	