Movement with the Moon: White-tailed Deer Activity and Solunar Events

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Abstract: White-tailed deer (*Odocoileus virginianus*) activity patterns are predominately crepuscular. However, the general populace believes that deer activity is also influenced by lunar factors. This belief is demonstrated by the countless "solunar charts" claiming to provide peak periods of deer activity. While research has identified solar and lunar influences on behavioral patterns in some species, descriptions of solunar factors on white-tailed deer are rare. Our goal was to evaluate whether solunar charts can predict periods of increased activity in white-tailed deer. We used 38 adult male, white-tailed deer equipped with GPS collars programmed to collect locations every 30 minutes from August–December during 2010–2012. Deer were classified as active or inactive based on total distance moved between consecutive GPS fixes. We used logistic regression to estimate the odds of activity dependent on solunar events. Based on our results, on those days furthest from the full or new moon, deer were less likely to be active during moonrise and moonset periods, and more likely to be active during moon overhead and moon underfoot periods. On days with greater proximity to the new or full moon the probability of activity during moonrise and moonset periods increased from 0.384 (SE = 0.005) to 0.564 (SE = 0.010) and 0.403 (SE = 0.005) to 0.591 (SE = 0.011), respectively, while decreasing during moon overhead and moon underfoot periods from 0.540 (SE = 0.005) to 0.413 (SE = 0.011) and 0.516 (SE = 0.005) to 0.305 (SE = 0.010), respectively. Our data suggest events identified by solunar charts have some association with deer activity. However, the relationships between lunar events and lunar phase expressed in solunar charts may be misleading.

Key words: solunar charts, white-tailed deer, hunting, deer movement, solunar

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Animal movements are influenced by a variety of factors ranging from physiological requirements to short term weather events (Ran et al. 2008). Lunar phase has been suggested to play a major role in movement patterns of all species, with multiple studies documenting the influence of lunar phases and cycles on animal movement patterns. For example, prey species such as the kangaroo rat (*Dipodomys spectabilis*; Daly et al. 1992) and snowshoe hare (*Lepus americanus*; Griffin et al. 2005) reduce nocturnal activity during brightly illuminated nights, caused by the full moon, in an effort to decrease predation risk (Lima and Dill 1990, Sabato et al. 2006). Similarly, reduced prey availability has been found to decrease predator activity in the maned wolf (*Chrysocyon brachyurus*; Sabato 2006) and white-throated round-eared bat (*Lophostoma silvicolum*; Lang et al. 2006). Although lunar phase and illumination impact daily activity patterns of many species, lunar phase also appears to influence activity in relation to key life history events. Examples include horseshoe crabs (*Limulus polyphemus*; Barlow et al. 1986) and various fish species (Takemura et al. 2004) whose peak of breeding occurs near the full and new moons, along with Barau's petrels (*Pterodroma baraui*) whose mean arrival date to their breeding colony is closely associated with the full moon phase (Pinet et al. 2011). An additional lunar factor with the potential to influence animal activity is the position of the moon in the sky. Though there is a paucity of research detailing the impact this factor has on animal movement, Brown (1954) found that when removed from their tidal water bodies, oysters (*Ostrea virginica*) have daily activity peaks associated with moon overhead and moon underfoot periods. However, a similar trend has yet to be documented in other organisms.

The hunting public has come to believe that lunar factors influences animal movement patterns, and this is particularly apparent among white-tailed deer (*Odocoileus virginianus*) hunters (Webb et al. 2010). While entirely anecdotal, this belief is perpetuated via regular discussion in the non-scientific (e.g., popular) literature (Taylor 1985, Alsheimer 1999, Couch 2014). One lunar factor commonly believed to impact deer activity is lunar phase, although peer-reviewed works have failed to document any association between lunar phase and white-tailed deer activity (Michael 1970, Zagata and Haugen 1974, Beier and McCullough 1990, Webb et al. 2010). Hunters have also expressed a belief that the location of the moon may influence deer activity, an idea popularized by John Alden Knight through his book, "Moon Up—Moon Down" (Knight 1942). Within this text, Knight suggests that animal activity increases during periods of time around four solunar events: moon rise (RISE), moon set (SET), moon overhead (OVERHEAD), and moon underfoot (UNDERFOOT). Today many companies provide products known as "solunar charts" based on Knight's claims. These charts report periods of time that animals should be more active with windows around moon OVERHEAD and moon UNDERFOOT represented as major periods and moon RISE and moon SET represented as minor periods. Though solunar charts all appear to follow the same general trends suggested by Knight (1942), there tend to be minor variations between charts, such as predicted periods differing in length by a half hour. Solunar charts also often report a ranking for each day based upon lunar phase (Roseberry and Woolf 1986), where days are ranked from 1–4 with 4 being the period of the most predicted deer activity. The greater the proximity to the new or full moon, the closer to 4 that particular day's rating will be. However, as with major and minor period prediction, there tends to be slight variation between solunar charts regarding day rank. The relationship between lunar phase and deer activity implied by this ranking system is not that deer will increase total activity near the full and new moons, but instead that the position of the moon in relation to the sun during these phases magnifies the effect of solunar periods, leading to increased activity during the predicted windows (Knight 1942).

While solunar charts tend to be very popular within the deer hunting community, there has only been one published study (Roseberry and Woolf 1986) that evaluated the validity of solunar charts. Roseberry and Wolfe (1986) found that during fall, deer were more active on days with higher ratings than on poorly rated days, yet this trend was not seen during winter. Roseberry and Woolf (1986) also reported that deer were not found to be significantly more active within the solunar periods they observed than during non-solunar periods for either season. However, the data were collected using visual observations of unmarked deer; thus there is the potential for more advanced technology to detect patterns that were not apparent to the naked eye. In order to evaluate the relationship between solunar events and deer activity patterns we collected GPS data on white-tailed deer activity patterns to compare these patterns to lunar events and phases. Our specific objectives were to determine if: (1) deer display elevated activity during the periods of time surrounding lunar events identified in solunar charts, and (2) deer display elevated activity during predicted periods with higher rankings. If the relationships with lunar position and lunar phase suggested by solunar charts accurately predict deer activity, then activity rates should be greater during predicted windows than surrounding windows, and activity rates should be greatest on highly ranked days.

Methods

Study Area

Our research was conducted at Brosnan Forest, a 5,830 ha tract of lower coastal plain habitat in Dorchester County, South Carolina (33.08591˚N, 80.25726˚W). This project took place exclusively on the 2,552-ha portion of the property located north of Highway 78. Approximately 93% forested, the study area contained mostly open longleaf pine (*Pinus palustris*) stands interspersed with mixed hardwoods (Collier et al. 2007). As the area was historically swampy prior to drainage, hardwood drains were found throughout the property. Mixed pine-hardwood areas were comprised of loblolly (*Pinus taeda*), slash (*Pinus elliottii*), and pond (*Pinus serotina*) pine, along with oak (*Quercus spp.*), sweetgum (*Liquidambar styraciflua*), and red maple (*Acer rubrum*). Bottomland drains included oak, sweetgum, black gum (*Nyssa sylvatica*), and yellow poplar (*Liriodendron tulipifera*). The majority of forest stands were actively managed for timber production, and burned on a 2–3 year rotation, maintaining an open understory (Lauerman 2007, Collier et al. 2007). Food plots on the study area ranged in size from 0.16 to 9.1 ha, and comprised a total of 126 ha. These plots were planted annually with a cool season mix of various clovers (*Trifolium spp.*), grains (oats, *Avena fatua*; wheat, *Triticum aestivum*; rye, *Secale cereale*), chicory (*Cichorium intybus*), and winter peas (*Pisum sativum*) (McCoy 2013). There were also 59 feeders distributed throughout the study area dispensing protein pellets during winter and shelled corn during the hunting season, which ran from 15 August–1 January.

Capture

During May-August of 2009–2011 a total of 38 male white-tailed deer (ranging from 1 to 4+ years, with a nearly uniform distribution) were immobilized via a 2-cc transmitter dart (Pneu-dart Inc., Williamsport, Pennsylvania) containing a Xylazine (Lloyd Laboratories, Shenandoah, Iowa; 100mg/ml given at a rate of 2.2 mg/kg) and Telazol (Fort Dodge Animal Health, Fort Dodge, Iowa; 100mg/ml given at a rate of 4.5 mg/kg) mixture. Deer were fitted with an ATS G2110D GPS Collar (Advanced Telemetry Systems, Isanti, Minnesota) tightened to within approximately two finger widths of the neck, allowing the collar to stay in the proper upright position and improving data accuracy (D'Eon and Delaparte 2005). After processing was complete a 3-ml intramuscular injection of Tolazoline (Lloyd Laboratories, Shenandoah, Iowa; 100mg/ml given at a rate of 6.6 mg/kg) was administered to act as a reversal to the Xylazine/Telazol mixture, and deer were observed until they moved away under their own power. All protocols involving animals were approved by the Auburn University Animal Care and Use Committee (PRN# 2008-1489).

Data Collection and Manipulation

GPS collars were programmed to take fixes at 30-minute intervals from 23 August–23 November, recording position in UTM coordinates, date, time, altitude, fix status, satellites, position dilution of precision (PDOP), horizontal dilution of precision (HDOP), and temperature with each fix. Collars automatically fell off the deer at the end of the study period and were collected via radio telemetry. Data were offloaded using ATS WinCollar software, and likely erroneous 3-dimensional fixes with PDOP > 10 or HDOP > 6 and 2-dimensional fixes with HDOP > 3 were removed (D'Eon and Delparte 2005, Lewis et al. 2007).

Following the lunar data acquisition method of Webb et al. (2010), the times of three lunar events, moon rise, moon set, and moon overhead, along with sunrise and sunset were downloaded from the naval observatory website, for Summerville, South Carolina (≈20 miles from the study site). As the fourth lunar event, moon underfoot, was not reported, this event was estimated as half way between moonset and moonrise. Any events reported in daylight savings time were converted to standard time so as to maintain consistency across datasets. Times were then set to match the nearest half hour interval of the GPS fix schedule, and three hours before and after every solunar event were denoted in half hour increments. Similar windows, lasting only 1.5 hours before until 1.5 hours after, were built around sunrise and sunset. All points were classified as taking place during either the day or night, with day representing times within legal hunting hours. Additionally, the ranking for each day as reported by Solunar Forecast (2015) a popular online solunar chart, was applied to each GPS location using a scale of 1–4, with 4 representing the highest rated days. Given proximity to the new and full moons is the primary driver behind day rank, changes in activity corresponding to an increase in day rank can be interpreted as the result of increasing proximity to the new and full moons. As there are only minor differences between the numerous solunar charts available, the ranking system from this single chart was sufficient to represent the ranking system used in all solunar charts.

To determine locational error, three collars were deployed for five days at the end of the research period among various habitat types found within the study site: an immature pine stand, a mature pine stand, and a mature hardwood stand. Collars were placed approximately 1 m above the ground, the neck height of a standing deer (Frair et al. 2010), with the antenna pointing directly upwards (Lewis et al. 2007, D'Eon and Delparte 2005, Frair et al. 2004). Coordinates for the deployment locations were taken with a Trimble GeoXT GPS unit, with all locations accurate to within 1 m. As all collars were of the same model, the assumption was made that each collar had comparable precision and that any variance between collars was habitat driven (Lewis et al. 2007). The Euclidean distance of each fix from its corresponding known location was calculated ($\bar{x} = 12.95$ m, SD = 9.81 m) and the mean locational error was multiplied by 4 to determine a distance threshold of 51.78 m. This threshold represented the minimum Euclidean distance between consecutive fixes to be certain that movement had occurred and was utilized to classify all consecutive fixes as active or inactive. This threshold meets the minimum necessary distance of 5 error standard deviations suggested by Jerde and Visscher (2005) to be certain movement occurred. Activity was treated as a binary variable to allow examination of if activity rates changed surrounding solunar events. Treating this movement as a continuous variable would suggest that an animal with further displacement is more active than an animal browsing through an area and would reduce the ability to detect changes in activity rates.

Data Analysis

We developed nine candidate models, using varying predicted periods of deer movement, for each of the four solunar events. The predicted periods ranged in duration from one hour before and one hour after to two hours before and two hours after the solunar event being tested. The time remaining within the overall six-hour window surrounding each event was used as a bordering period. We used logistic regression to compare the odds of activity during any 30-minute interval within the predicted window to the odds of activity during any 30-minute interval within the bordering times, using day rank as an interaction term. The only change between models was the length of the predicted period while the base model, activity = predicted period + predicted period * day rank, remained constant. The model with the lowest Akaike's Information Criterion (AIC_c) rank was the best fit for each of the four solunar events (Burnham and Anderson 1998). We exponentiated the beta estimates to determine the comparative odds of activity during any given 30-minute interval within the predicted versus bordering periods of each solunar event as day rank increased.

The probability of activity during a given half hour interval along with its standard error was calculated for the predicted and bordering periods of each solunar event by day rank. Intervals which were not classified due to missed fixes were excluded in the creation of fit. Probability of activity during a given half hour interval was also calculated for five reference periods: the entirety of the study period (24-HOUR), half an hour before sunrise to half an hour after sunset (DAY), half an hour after sunset until half an hour before sunrise

(NIGHT), 1.5 hours before until 1.5 hours after sunrise (SUNRISE), and 1.5 hours before until 1.5 hours after sunset (SUNSET). All analysis was conducted in R (R Core Development Team 2015).

Results

The 38 collars deployed throughout the experiment had an average fix rate, after data censoring, of 81.54% ($n = 153{,}077$) while the stationary collars had an average fix rate of 99.87% ($n = 792$). Our model selection results indicated that the period from 2 hours before until 1.5 hours after moon RISE was the best fitting model, given the data, while the periods from 2 hours before until 1 hour after were the best fitting models, given the data, for moon SET, moon OVERHEAD, and moon UNDERFOOT (Table 1; Table 2). The probability of activity during any given half hour interval throughout our study period was 0.465 (SE = 0.003, $n = 124{,}825$), and remained nearly constant as day rank increased from 1 to 4 (Figure 1). This consistency across day rank was also seen for the probabilities of activity during the night, day, sunrise, and sunset, which had values of 0.596 (SE = 0.004, $n = 58{,}576$), 0.348 (SE = 0.003, $n = 66{,}249$), 0.578 (SE = 0.007, $n = 17{,}635$), and 0.634 (SE = 0.007, $n = 18{,}090$), respectively.

Deer were 2.351 (CI = 2.208–2.494) and 2.806 (CI = 2.666–2.946) times as likely to move during any half hour interval of the predicted versus bordering periods, as determined by the best fit model, surrounding moon RISE and moon SET, respectively, on 4-star days as they were during 1-star days (Table 3). However,

Table 1. Candidate models, number of model parameters (K), Akaike's Information Criterion (AIC_c), and associated model ranks (ΔAIC_c) and model weights (w_i) used to predict periods of peak male white-tailed deer activity surrounding moonrise, moonset, moon overhead, and moon underfoot at Brosnan Forest, South Carolina.

Solunar event	Hours before[a]	Hours after[b]	K	AIC_c	ΔAIC_c	w_i
Constant			1	172420.90		
Moonrise	2.0	1.5	8	44108.59	0.00	0.93
	2.0	1.0	8	44114.09	5.50	0.06
	1.0	1.0	8	44118.59	10.00	0.01
	1.0	1.5	8	44118.92	10.33	0.01
	1.5	1.5	8	44121.79	13.20	0.00
	1.5	1.0	8	44124.05	15.46	0.00
	2.0	2.0	8	44129.19	20.60	0.00
	1.0	2.0	8	44141.57	32.98	0.00
	1.5	2.0	8	44143.42	34.83	0.00
Moonset	2.0	1.0	8	44582.64	0.00	0.92
	2.0	1.5	8	44587.56	4.92	0.08
	1.5	1.0	8	44594.86	12.23	0.00
	1.5	1.5	8	44611.89	29.25	0.00
	1.0	1.0	8	44633.05	50.42	0.00
	1.0	1.5	8	44658.01	75.38	0.00
	2.0	2.0	8	44663.87	81.24	0.00
	1.5	2.0	8	44691.91	109.28	0.00
	1.0	2.0	8	44733.69	151.05	0.00
Moon overhead	2.0	1.0	8	44877.72	0.00	0.79
	2.0	1.5	8	44880.32	2.59	0.21
	2.0	2.0	8	44895.78	18.05	0.00
	1.5	1.0	8	44899.75	22.02	0.00
	1.5	1.5	8	44906.00	28.28	0.00
	1.5	2.0	8	44922.77	45.04	0.00
	1.0	1.0	8	44927.86	50.14	0.00
	1.0	1.5	8	44934.75	57.02	0.00
	1.0	2.0	8	44948.79	71.07	0.00
Moon underfoot	2.0	1.0	8	44227.28	0.00	1.00
	2.0	1.5	8	44240.90	13.62	0.00
	1.5	1.0	8	44257.58	30.30	0.00
	2.0	2.0	8	44259.77	32.49	0.00
	1.0	1.0	8	44271.50	44.22	0.00
	1.5	1.5	8	44272.89	45.61	0.00
	1.0	1.5	8	44287.39	60.11	0.00
	1.5	2.0	8	44289.21	61.93	0.00
	1.0	2.0	8	44302.46	75.18	0.00

a. The length of time prior to the solunar event included in the window of predicted activity

b. The length of time after the solunar event included in the window of predicted activity

Table 2. The coefficient estimates of the top model used to predict periods of peak male white-tailed deer activity surrounding moonrise, moonset, moon overhead, and moon underfoot, respectively, for male white-tailed deer at Brosnan Forest, South Carolina.

Coefficient	Moonrise	Moonset	Moon overhead	Moon underfoot
Predicted Period	–0.310	–0.287	0.162	0.128
Day Rank 2	0.206	0.190	–0.088	–0.123
Day Rank 3	0.035	0.097	–0.146	–0.309
Day Rank 4	–0.126	–0.270	–0.176	–0.585
Predicted Period*Day Rank 2	0.255	–0.095	–0.559	–0.387
Predicted Period*Day Rank 3	0.533	0.468	–0.457	–0.547
Predicted Period*Day Rank 4	0.855	1.032	–0.335	–0.300

Table 3. The comparative likelihood of activity within predicted solunar periods versus corresponding bordering periods as interacted with day rank for male white-tailed deer at Brosnan Forest, South Carolina.

Solunar event	Day rank	Estimate	SE	*P*	Likelihood[a]
Moonrise	2	0.255	0.079	0.001	1.290
	3	0.533	0.060	< 0.001	1.704
	4	0.855	0.073	< 0.001	2.351
Moonset	2	–0.095	0.077	0.221	0.910
	3	0.468	0.058	< 0.001	1.597
	4	1.032	0.072	< 0.001	2.806
Moon overhead	2	–0.559	0.080	< 0.001	0.572
	3	–0.457	0.059	< 0.001	0.633
	4	–0.335	0.072	< 0.001	0.715
Moon underfoot	2	–0.387	0.080	< 0.001	0.679
	3	–0.547	0.061	< 0.001	0.579
	4	–0.300	0.075	< 0.001	0.741

a. Likelihood represents the exponentiated effect estimate provided by logistic regression, comparing likelihood of activity during any half hour interval to the same event with a day rank of 1

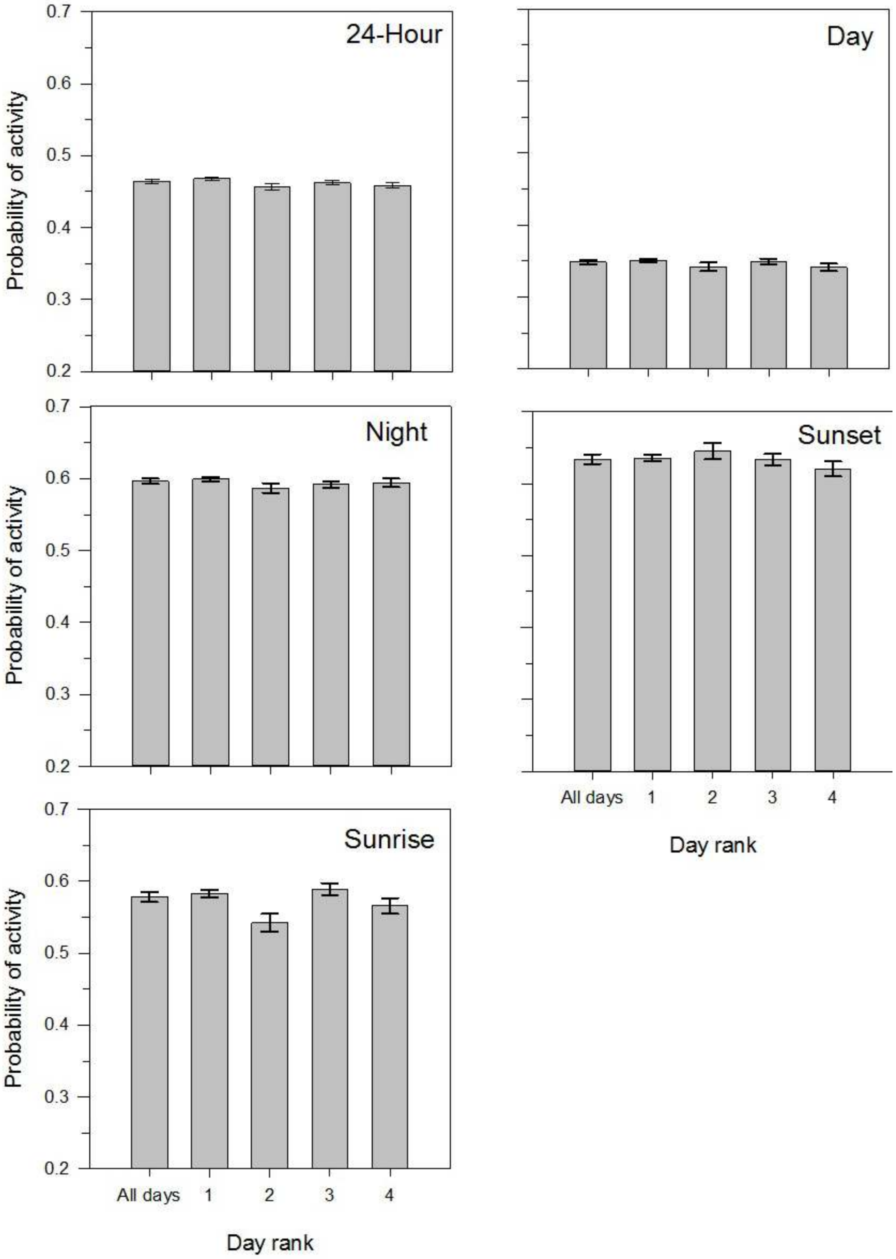

Figure 1. The probability of white-tailed deer activity during any half hour interval within five periods: the entire study period, day, night, around sunrise (1.5 hours before until 1.5 hours after), and around sunset (1.5 hours before until 1.5 hours after) at Brosnan Forest, South Carolina. Error bars represent one standard error.

for the predicted versus bordering periods surrounding moon OVERHEAD and moon UNDERFOOT, deer were only 0.715 (CI = 0.575–856) and 0.741 (CI = 0.595–0.887) times as likely, respectively, to be active on 4-star days compared to 1-star days. As day rank increased from 1 to 4, probability of activity during any half hour interval of the predicted moon RISE and moon SET periods increased from 0.384 (SE = 0.005, *n* = 11,458) and 0.403 (SE = 0.005, *n* = 10,321) to 0.564 (SE = 0.010, *n* = 2,992) and 0.591 (SE = 0.011, *n* = 2,095), respectively, while decreasing during moon OVERHEAD and moon UNDERFOOT predicted periods from 0.540 (SE = 0.005, *n* = 10,656) and 0.516 (SE = 0.005, *n* = 10,793) to 0.413 (SE = 0.011, *n* = 1,907) and 0.305 (SE = 0.010, *n* = 1,987), respectively (Figure 2).

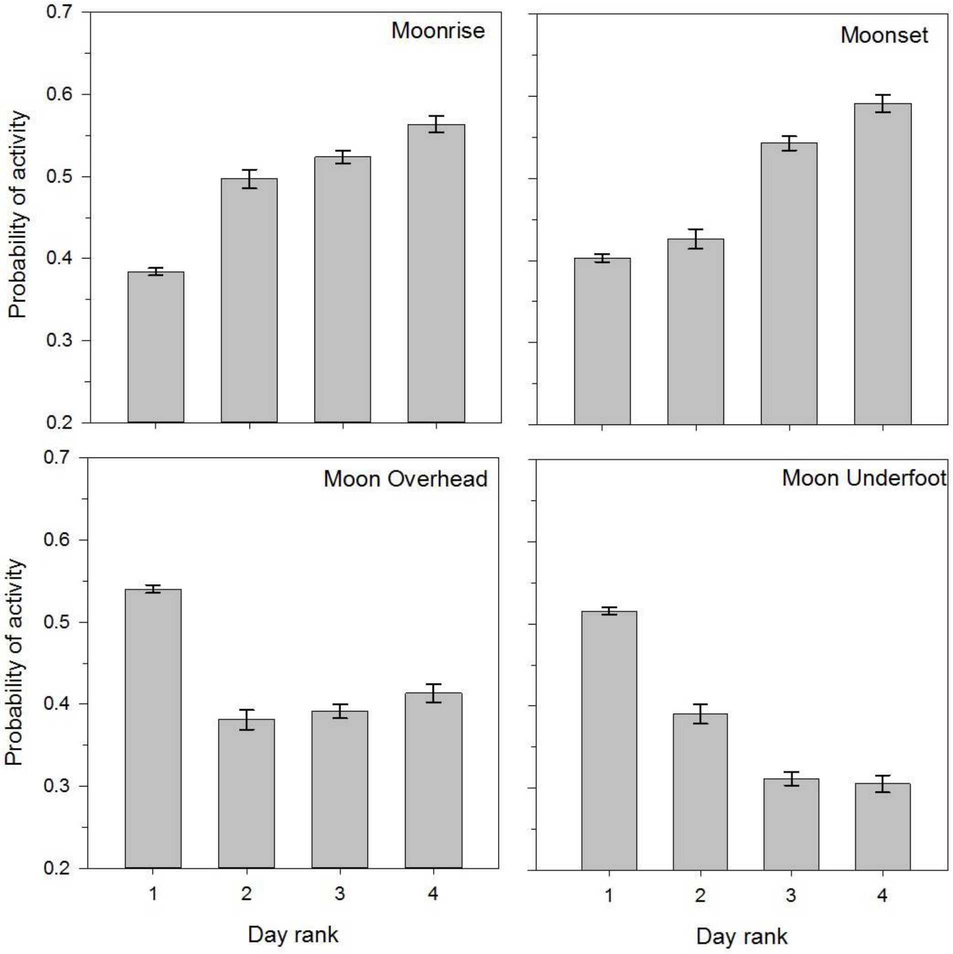

Figure 2. The probability of white-tailed deer activity during any half hour interval within the predicted windows for each solunar event at Brosnan Forest, South Carolina. Error bars represent one standard error.

Discussion

Our data suggest that there is a varied relationship between male white-tailed deer activity, solunar events, and moon phase. This relationship is characterized by two distinct trends; deer become more active during the periods predicted by the best fit model for moon RISE and moon SET, and less active during the predicted periods for moon OVERHEAD and moon UNDERFOOT, as proximity to the new and full moons becomes greater. This can be summarized as a positive relationship between deer activity and proximity to the new and full moon during moon RISE and moon SET and a negative relationship between proximity to the new and full moon and deer activity during moon OVERHEAD and moon UNDERFOOT. A relationship between the position of the moon in the sky and animal activity had previously only been documented in oysters (*Ostrea virginica*; Brown 1954). Brown (1954) found that following removal from tidal waterways, oysters would express peaks in feeding activity when the moon was directly overhead and underfoot, and documented that these peaks increased in intensity during the new and full moons. In concurrence with Brown (1954), our study also documented change in the intensity of activity surrounding moon OVERHEAD and moon UNDERFOOT periods associated with change in proximity to the new and full moons. However, while oyster activity during these solunar events had a positive association with the new and full moons, deer activity had a negative association.

While supported by the data collected in this study and previous findings in oysters, the observance of a relationship between white-tailed deer activity and solunar events contradicts the results of a previous study with white-tailed deer. Roseberry and Woolf (1986), observed deer on Crab Orchard National Wildlife Refuge at 15-minute intervals during diurnal hours from elevated stands. They found no difference in deer activity during the periods of time surrounding solunar events versus non-solunar periods. However, the results reported by Roseberry and Woolf (1986) may have been influenced by data collection methods, as they were only able to observe deer during daylight hours and were limited to collecting data from deer that were visible. Due to GPS technology, we were able to continuously document deer activity regardless of their location on the study area or the time of day. Roseberry and Woolf (1986) also failed to take moon phase into account, potentially allowing cyclical changes which could average out over the course of a month to be masked.

While the data from our research found relationships between deer activity and lunar factors that had previously not been documented, other trends observed in our data corroborated deer activity patterns that had previously been documented. Deer activity during day, night, around sunrise, around sunset, and throughout the entire 24-hour period did not seem to be affected by proximity to the new or full moon. Though our study focused on proximity to the new and full moon and categorized days accordingly, Webb et al. (2010) categorized moon phase as either new, crescent, quarter, gibbous, or full. Even with this approach, no difference in overall activity was found for male or female white-tailed deer in relation to moon phase, a conclusion supported by other previous studies (Michael 1970, Zagata and Haugen 1974, Beier and McCullough 1990). Interestingly, peak values associated with the probability of activity for each solunar event were most comparable with the probability of activity found around sunrise. Deer have a greater probability of activity during the respective peaks of each solunar event than during any given half hour interval during diurnal hours, while still being less active than during the period surrounding sunset. This indicates that while deer do have increased activity rates during various solunar periods as a function of moon phase, the crepuscular hours surrounding sunset appear to be when deer are most likely to be active, which was already commonly accepted (Beier and McCullough 1990, Webb et al. 2010).

Although we detected relationships between solunar events and white-tailed deer activity, there are problems with the manner in which solunar charts express the relationship between deer activity, solunar events, and moon phase. A primary concern with solunar charts is found in the conflicting relationships with moon phase between solunar events. The existence of these conflicting trends suggests that the day ranking system currently used by solunar chart producers is not an effective predictor of deer activity, as it only correctly identifies peak periods of activity for moon RISE and moon SET. In contrast, peak periods of activity associated with moon OVERHEAD and moon UNDERFOOT are not well-predicted by day rank. As a result, solunar charts will have a natural tendency to accurately predict periods of activity only half the time. A second, but perhaps less fundamental issue with solunar charts is that classifying moon RISE and moon SET as minor periods while classifying moon OVERHEAD and moon UNDERFOOT as major periods is misleading. The greatest probabilities of activity for moon RISE and moon SET, which occurred on days closest to the new and full moon, were actually greater than the peak values for moon OVERHEAD and moon UNDERFOOT, which occurred on days furthest from the new and full moon. These differences suggest that solunar chart developers need to reconsider their use of day rankings.

Our findings should not be interpreted as suggesting that deer have increased susceptibility to hunter harvest during solunar periods, as increased activity does not necessarily increase a deer's vulnerability to harvest. While a deer may increase its activity during predicted solunar periods, it may remain in areas that are not accessible to hunters or it may avoid permanent hunting stand locations, a behavior which has been documented in studies of deer behavior during the hunting season (Pilcher and Wampler 1981, Naugle et al. 1997, Kilgo et al. 1998, Kilpatrick et al. 2002, Rhoads et al. 2013). Additionally, our research focused solely on examining relationships between activity (e.g., a deer changed locations during a 30-minute period) and lunar periods commonly defined in solunar charts. We examined these relationships only during a period that included both the breeding season and hunting season on our study area. It is possible that the propensity for deer to be active during these defined periods may vary with season, environmental factors, habitat, and hunting pressure. Finally, as we only examined data for males, it is possible that females display differing patterns of activity.

Acknowledgments

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