WHITE-TAILED DEER ACTIVITY, CONTRACEPTION, AND ESTROUS CYCLING

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Abstract: Reliable activity measures in free-ranging white-tailed deer could be useful for the assessment of estrous cycling and general activity changes that can occur after immunocontraceptive vaccine treatments. Electronic data-logging (Countcard™) devices attached to 9 white-tailed doe deer on neck collars were used to monitor their movement activities during 2 rutting seasons in 2.5 acre fenced enclosures. Direct daily behavioral observations on buck responses toward individual does were used to detect estrus and to validate changes in 24-hour activity counts as another indication of estrous cycling. When individual activity counts for the estrus days on the does were compared to diestrus counts as estimated by mean values over days 10 through 15 post-estrus, a significant high product moment correlation of 0.946 was obtained indicating similar and proportional changes in activity under the 2 behaviorally-detected conditions. As predicted, mean activity counts for the estrus days were significantly higher (P<0.0039) than the mean counts for the diestrus days. This indicated some potential utility for the devices as sensors for estrus detection. Even though the individual deer showed different activity baseline levels and a high degree of daily variation, estrus days were frequently characterized by minor peaks in the daily activity counts followed within a day or a day and a half by a sharp activity decline, an indication that the does were at this point receptive to mounting by bucks.

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Key Words: deer activity, contraception, data-logger, estrous cycle, *Odecoileus virginianus*

Control of localized white-tailed deer (*Odecoileus virginianus*) populations using immunocontraceptive treatments is a potentially attractive wildlife management technique in terms of social acceptance, humaneness, and feasibility (Kirkpatrick and Turner 1991; Turner, Liu and Kirkpatrick 1992; Turner, Kirkpatrick and Liu 1996; Mc Shea, Wemmer and Stuwe 1993). In some areas of the Northeastern and Midwestern U. S., hunting and other management methods have failed to stem deer overpopulation levels. As a result, damage to fruit trees, vegetable gardens and ornamental plantings; automobile and ground aircraft traffic hazards; and the spreading of Lyme disease from ticks have been identified as deer-related problems. In newly sub-divided rural areas adjacent to urbanized cities, individual land owners are often opposed to hunting as a deer management method, and prefer to apply repellents or to alter habitats. Because these methods may achieve only temporary or partial reduction of the deer-related problems, immunocontraception is viewed as an attractive possibility for a more permanent solution.

Although Porcine Zona Pellucida (PZP) treatment has been demonstrated to be a highly effective immunocontraceptive for preventing pregnancies in white-tailed deer, treated does also show extended estrous cycling beyond the normal rut season (Turner et al. 1992; Shumake and Wilhelm 1995) and 3 or 4 extra cycles are not uncommon. Gonadotropic releasing hormone (GnRH), on the other hand, will generally reduce reproductive behaviors in both sexes with extended treatment leading to regression and atrophy of the gonads (Kirkpatrick and Turner 1991). The overall effects of the absence of estrus in does on buck behavior have not been fully documented.

Bucks are normally attracted to powerful chemosignals generated in does at the time of estrus (Murphy et al. 1994) and their behavior toward individual does can be used to detect receptive animals. It may be also possible to detect the time of estrus in individual does by either a slight change in doe body temperature or movement activity as is the case with dairy goats and cows (Doherty et al. 1987; Redden et al. 1993). The objectives of the 1995-1996 study were: (1) to evaluate the effects of PZP treatment on buck pursuit/mounting/copulation, and (2) to determine whether neck-collar-mounted Countcards™ could be used to detect behavioral estrus in PZP-treated does. Objectives of the 1996-1997 study were: (1) to compare the effects of PZP treatment in 4 previously dosed does with 4 control does treated with vehicle only, and (2) to evaluate the neck-collar-mounted count card sensors on both PZP-treated and control doe deer. Detection of estrus in the white-tailed doe deer was accomplished by observing the behavior of bucks housed in enclosures with small doe herds at the Deer Research Facility during 2 rut seasons. Statistical correlations and comparisons between the movement activity counts for individual does during detected estrus and the counts for diestrus days were performed. This allowed an assessment of the Countcard™ data logger devices as a potential means of estrus detection.

STUDY AREA

Both studies were conducted at the Pennsylvania State University Deer Research Facility, University Park, PA. The facility consists of a 22 acre enclosure with high fencing for the captive management and propagation of white-tailed deer. The area is further divided into 9 paddocks or sub-enclosures, each separated by 8 ft (2.44 m) diamond mesh wire fencing, and topped with 3 strands of barb wire. A centrally-located runway building is used for handling, weighing, blood sampling, injecting, and examining the animals. The first study extended over 107 days from November 8, 1995 through February 22, 1996. The second study lasted 86 days from November 8, 1996 through February 3, 1997.

METHODS

Observation Procedures

To detect behavioral signs of estrus in each of the does for the 1995-96 rut, observations were made by trained staff twice per day from 0800 to 0900 EST and from 1600 to 1700 EST. In addition, reproductive behaviors were observed at other hours during the day by Deer Research Center staff. Individual does were identified by their ear tag colors and by numbers. For does with similar tag colors, a small patch of hair was shaved on unique areas of their bodies. The complete list of tag numbers, colors, and shave marks was made available to all observers. Animals were identifiable from a minimum of 20 yards from all locations within the 2.5 acre paddock.

For the 1996-97 rut, observation procedures were identical to those described for the previous year's rut. All animals were observed 3 times per day over 1-h intervals (0800 to 0900, 1130 to 1230, and 1600 to 1700 EST) throughout the 86 days of observation. Individual doe interactions with the bucks were again recorded on data sheets in the pen enclosure and periodically on videotape recordings for later comparisons of activity and behavioral signs of estrus in the does as extrapolated by buck interest.

Data Logger Devices

Countcard™ devices are credit card sized data logger units that can be preprogrammed to automatically sense and record daily movements. The devices are normally used to monitor automobile and truck highway traffic and are imbedded into the road surface. Operational detection is achieved by disturbances in the earth's magnetic field forces as the vehicles pass over the device. The Countcard™ units will, however, also register movement counts when they are moved themselves. Data generated in this manner are based on discrete episodes or bouts of movement activity. In other words, rapid movement of the devices without interruption will not register high activity counts, but repetitive stop-and-start movements are registered. This use of the devices has some advantage in terms of filtering some forms of rapid activity (e.g. scratching), but also has a disadvantage of not registering extended movements (e.g. long distance running) unless interrupted by pauses. A method for mounting the devices inside of plastic project boxes (Radio Shack®, Tandy Corp., Fort Worth, Tex.) and then onto neoprene deer collars (Advanced Telemetry Systems, Isanti, Minn.) was developed for attachment to individual does.

Determining Behavioral Estrus

For the 1995-96 rut, does were equipped with model NC-30X Countcard™ devices (Nu-Metrics, Uniontown, Penn.) and were previously treated with PZP vaccine in 1992, 1993, and 1994. They were not re-boosted with vaccine injections prior to the Fall 1995-96 rut. This initial deer herd size was 17, including 9 PZP-treated and 8 GnRH-treated does. Because no does in the GnRH group were instrumented with Countcard™ devices, their observed behaviors are not reported here. Of the PZP-treated does, 5 animals were monitored with devices (#0033, #0040, #0049, #228, and #327).

For each observation period, student observers entered the paddock, located the buck(s), and verified individual ear tags using binoculars. For the remainder of the observation period, the behaviors of 1 to 3 bucks and the responses of individual does were observed from the maximal distance that allowed animal identification. For each encounter in which the buck(s) showed an interest in a doe, rut behaviors were classified and recorded as one of eight categories as further described in Table 1.

Table 1. Eight categories of rutting behavior in white-tailed deer used to detect estrus in does.

Behavioral Category (Level)	**Brief Description**
No Interest 0	No male displays any interest in activities of a given doe. The doe is assumed to be in diestrus.
Following/Standing/Lying 1 within 8 yards	The buck visually orients in the direction of the doe and may exhibit urine sniffing and the Flehmen response. The buck and doe are observed together, either walking or bedding down, for a period of at least 15 minutes.
Short Pursuit 2	The buck follows the doe wherever she moves in the paddock, for a period of less than 2 minutes. While exhibiting this activity, the couple is frequently observed standing within 8 yards of one another.
Extended Pursuit 3	This is the same description as listed above for short pursuit, but the activity is continued over at least a 5 minute interval.
Aggressive Guarding/Pursuit 4	Highly aggressive behavior is shown by the buck toward any other male that approaches a doe in estrus. If the doe attempts to escape from this buck, the alpha male, he continually pursues her.
Female Stands for Male 5	This activity involves the buck licking the urogenital area of a receptive, estrous doe, with a mounting attempt. This is often accompanied with the buck resting his chin on the back of the doe. At this time, the alpha male aggressively defends the doe from pursuits of other bucks.
Mounting and Copulation 6	The doe allows mounting and copulation. Often, the doe will step out from under the buck on his first few mounting attempts. Actual mating lasts only 8-15 seconds and is therefore rarely observed.
Post Copulatory Posture 7	These postures exhibited by does typically follow a successful copulation, where ejaculation has occurred. The posture of the doe consists of a urination stance (legs spread, tail raised, and a hunched back). The buck may also urinate at this time.

All data were recorded manually and were documented on videotape. The recorded data sets were later analyzed to extrapolate the time periods in which each doe came into estrus. Repeated estrous cycling was a strong indication that the doe was not pregnant even though matings may have been repeatedly observed.

For the 1996-97 rut, student observers were employed again to make the 3, 1-h observations each day of the test. Inclement weather conditions as well as disturbances due to humans, dogs, and construction activities were noted each day in an attempt to account for potential aberrations in the doe activity. The same 8-category scale of buck interest toward individual does (Table 1) was used for detection of behavioral estrus in each instrumented animal. Countcard™ collars were installed on 8 deer. Five of the animals (i.e., #0001, #0040, #0049, #139, and #228) had been previously treated with the PZP vaccine but had not received booster vaccinations since 1994, and 3 of the animals (i.e., #661, #793, and #8108) had never received the PZP vaccine treatment. Animals were included as a part of a herd of 18 does penned together in a single enclosure with 1 to 3 bucks.

Data Analyses

Descriptive analysis involved tabulation of the number of estrous cycles observed in each doe treatment group. For the 1995-96 rut, final fawn birth data were tabulated by July 19, 1996, for comparisons of contraceptive efficacy among treatments. To evaluate the degree of proportional changes in movement activity counts for behaviorally-detected estrus versus diestrus days, correlation analyses were performed. Differences in the daily movement activity count means for the estrus versus diestrus conditions were compared with Student paired t-tests and Wilcoxon signed rank tests to assess the potential of using doe movement counts to serve as a supplemental method of estrus detection.

RESULTS AND DISCUSSION

1995-96

Data for the 1995-1996 rut were obtained from only 3 of the 5 Countcard™ devices on the collared does (#0033, #0049 and #228) when down-loaded manually or via computer through the serial port. Reasons for failure to obtain movement activity count data on does #0040 and #327 remain obscure. Reasons were probably not related to battery failure, but were most likely due to programming errors since the obtained outputs were in the form of counts per hour rather than counts for the previous 24-h period. Neither of these 2 does showed signs of estrus as detected by observation of buck behavior after November 23, 1995. Table 2 is a summary of the number of estrus cycles as detected by buck behavior directed toward the 3 does that yielded movement activity count data over the 107-day observation interval. Countcard™ movement activity data for selected observation days when estrus was detected by buck behavior are included along with the mean movement count values for days 10 through 15 post-estrus (diestrus). Daily changes in the movement counts, particularly for does #049 and #0033, indicated that a sharp increase or peak in activity did not necessarily correspond with an estrus day as detected by observers. With deer #228, there was an indication of a brief increase in movement activity counts followed by a sharp decrease. This would be a predicted pattern since the bucks normally show extended pursuit toward does in early estrus followed by a reduced movement of the does when they stand for the buck as he attempts to mount and copulate. In other words, when deer #228 was most receptive and allowed mounting, she also became relatively less active. The remaining 4 non-instrumented does showed up to 2 extra cycles with the last sign of estrus observed on February 11, 1996.

Of these 9 PZP-treated deer, 3 became pregnant and all had produced fawns by June 3, 1996. Deer #0033 produced a male and a female fawn on May 21, 1996 even though only the short pursuit category (level 2) of buck interest was observed and mounting attempts were never observed. Deer #327, also instrumented with a Countcard™, produced 3 female fawns but, unfortunately, no movement activity count data were obtained for this animal. The remaining doe, #16B, produced a single female fawn.

1996-97

During the 1996-1997 rut, count data were obtained for 3 control does (#0062, #661, #8108). There was again an indication of an increased movement activity count on the day that estrus signs were recorded by student observers as indicated in Table 2. Based on the 5-day means for the putative diestrus interval, there was an approximate 20 to 25 percent decrease in movement activity 10 days post-estrus.

Movement activity counts for does #661 and # 8108 reflected a high degree of variance within and between the untreated does. For example, whereas #661 showed extreme lapses of activity down to <1000 counts/day (i.e., days 2, 6, 7, 8, 11, 12, 14, 20 etc.), #8108 was more stable and never produced <4750 counts/day throughout the observation interval. At the time of this writing, the pregnancy rate for these animals as indicated by fawn births was unknown for this season, but no estrus signs for the 3 control does were recorded after the date of November 24, 1996 (i.e., Day 16).

PZP-treated animals that had not received booster immunocontraceptive vaccine for the past 3 years still continued to show repeated estrous cycling. There were 4 cycles detected for #0040, and all animals (i.e., #0001, #0040, #0049, #139, #228) showed estrus signs (as indicated by buck behavior) through the month of January, 1997 (i.e., Day 67). As with the previous year's rut, buck pursuit generally produced an increase in daily movement activity counts of does when estrus signs were first detected. The advanced categories of buck interest (e.g., mounting, aggressive guarding, copulation) were again sometimes correlated with generally below average daily activity counts. This pattern in doe activity at estrus was fairly consistent and repeatable within and between animals. For several animals (#0001, #0040, #139, and #228) pursuit responses by bucks produced higher daily counts followed within a day by lower counts when the does allowed buck mounting and copulation. The daily activity counts for deer #228 (Figure 1) exemplify the pattern of peaks followed by sharp declines that correspond with signs of estrus as recorded by the student observers.

Comparison of Movement Activity Counts and Estrus Detection

Assuming a nominal value of 25 days between estrus cycles for white-tailed deer, a 12-day post-estrus interval is a logical period of elapsed days for taking a 1-day sample of activity during diestrus. The prediction can be made that there should be consistently less movement activity (i.e., fewer proportional counts) on day 12 post-estrus when compared to the counts on the estrus-detected day. However, this was not confirmed by our data sets when a Pierson product moment correlation coefficient was calculated for the 9 collared animals. The *r* value was 0.3787 (not significant). However, both a Student paired t-test (T = 3.02, df = 8, P<0.0165) and a Wilcoxon signed rank test (P<0.004) on the data sets detected reliable differences between the 2-sample counts for each animal. Whereas the mean for diestrus days was 4718.0 Å 3304.3 and the mean for estrus days was 8224.5 Å 2665.7, the individual animal variation lowered the correlation value. With a low n of only 9 does, 1 or 2 animals with extremely low counts during diestrus can degrade the correlation coefficient value.

On the other hand, when a 5-day mean of the daily movement counts for days 10 through 15 post-estrus was used (instead of the 1-day count for 12 days post-estrus), a significant correlation was achieved ® = 0.946; T = 7.722, df = 7, P<0.00011). A paired t-test on the data set for estrus counts compared to the 5-day means for diestrus counts was significant (T = 6.187, df = 8, P<0.00026) as was a Wilcoxon signed rank test (P<0.0039). This 5-day-mean-count procedure tended to dampen the extremes for 2 does that showed disproportionately low counts during some days during the diestrus stage and thus improved the consistency of proportional activity changes. Both procedures were also influenced by 1 doe that had extremely low counts during both estrus and diestrus. Figure 2 shows a scatter plot of the correlated count measures using the mean-count procedure. Influences of other more subtle effects such as rain, snow, temperature, and human disturbance were also, at times, evident in the data set with some animals more sensitive than others to these disturbances. Despite these uncontrolled extraneous factors, a moderately consistent pattern of movement activity changes was detected in the data sets.

The consistent proportional decrease in movement activity counts for estrus days versus corresponding 5-day mean diestrus days ® = 0.946) implied that 89% of the count variation was accounted for by estrous cycling. If baselines for individual doe activity levels could be also factored into a detection equation algorithm, the activity data could become a useful additional means of detecting estrus in deer. A moderately high degree of predictive power for detection of estrus has been previously reported using body temperature and pedometer measurements in dairy cows (Redden et al. 1993). With captive white-tailed deer in small herd situations, a peak in activity followed by a sudden and sharp drop within 1 or 2 days of the peak may be a likely candidate for comparison with a 5-day mean estimate value for a potential diestrus interval. Variability between does and within the same animal was, however, a limiting factor in the predictive power and more experimental data will be needed to fully assess the potential of the devices. Studies will be continued in the Deer Research Facility pens and may be extended to field testing if results appear encouraging. Whether the Countcard™ devices could be useful for estrus detection in free-ranging field situations is unknown. However, the deer-movement effects of other management tools such as buffer-fencing, hunting to thin herds, or habitat modification probably could be monitored using these kinds of data logging devices. Devices are in fact available that would allow for deer movement activity monitoring with radio telemetry and remote down-loading of the data. These systems are, however, currently quite expensive (i.e., $2000 per doe vs. $250 per doe for Countcards™). This would either limit the number of does that could be monitored when working within a reasonable research budget or could easily become cost prohibitive when aircraft radio-tracking and other expenses are included.

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Figure 1. Daily activity counts for Deer #228 during the 1996-97 rut. Instances of buck interest are indicated for days 17, 41, and 67.

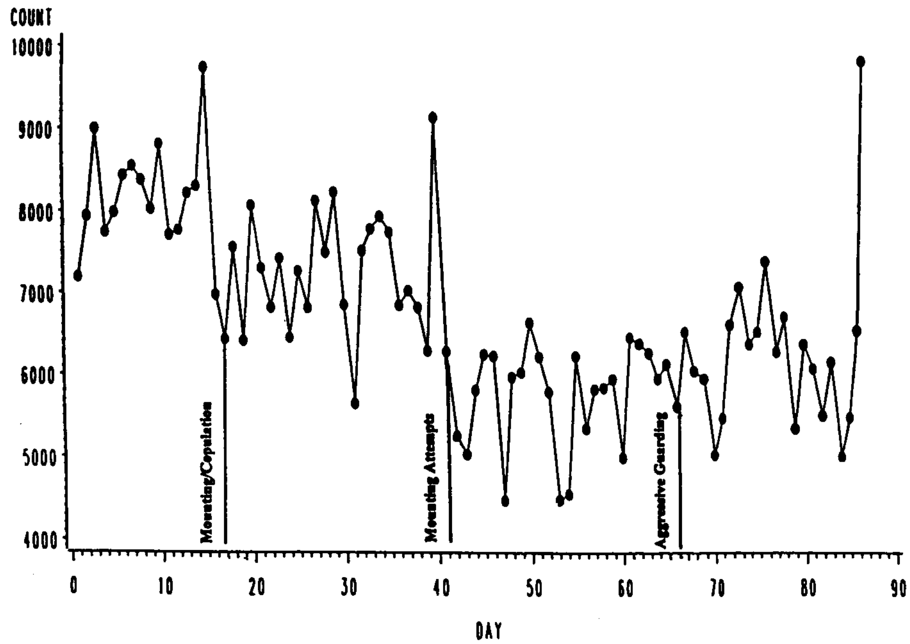

Figure 2. Scatter plot of movement activity counts on the day that estrus was detected through observation of buck behavior versus a mean count value for days 10 through 15 post-estrus for each of 9 white-tailed doe deer. The product moment correlation for these data (r = 0.946. P<0.000l) indicated proportionally decreased mean movement counts for diestrus compared to estrus counts. The decrease was also significant using a Wilcoxon signed rank test (P<.00039).