Faculty Publications   **Forestry**

2004

Daily Movements of Female White-tailed Deer Relative to Parturition and Breeding

Christopher E. Comer

Daily Movements of Female White-tailed Deer Relative to Parturition and Breeding

Gino J. D'Angelo, *Daniel B. Warnell School of Forest Resources, University of Georgia, Athens, GA 30602*

Christopher E. Comer, *Daniel B. Warnell School of Forest Resources, University of Georgia, Athens, GA 30602*

John C. Kilgo, *U.S. Forest Service Southern Research Station, USFS-Savannah River, P.O. Box 700, New Ellenton, SC 29809*

Cory D. Drennan, *Daniel B. Warnell School of Forest Resources, University of Georgia, Athens, GA 30602*

David A. Osborn, *Daniel B. Warnell School of Forest Resources, University of Georgia, Athens, GA 30602*

Karl V. Miller, *Daniel B. Warnell School of Forest Resources, University of Georgia, Athens, GA 30602*

Abstract: To assess how white-tailed deer *(Odocoileus virginianus)* herd demographics influence reproductive behaviors, we examined 24-h diel movements of female white-tailed deer relative to parturition and breeding in a low-density population with a near even sex ratio at the Savannah River Site (SRS), South Carolina. We conducted a series of intensive, 24-h radio-tracking periods of 13 females during spring and fall 2002. We compared daily range (ha), rate of travel (m/h), and distance between extreme daily locations (m), among the periods of pre-parturition and post-parturition and pre-, peak-, and post-rut. From pre-parturition to post-parturition, we observed decreases in diel range size (–38.2%), distance between extreme diel locations (–17.0%), and diel rate of travel (–18.2%). Diel range size, distance between extreme diel locations, and diel rate of travel during the pre-rut and rut exceeded those observed during post-rut. We further identified substantial increases in mobility during 12 24-h diel periods for eight females during our fall monitoring. Our data suggest that female white-tailed deer reduce mobility post-fawning following exaggerated movements during pre-parturition. Furthermore, despite a near equal sex ratio, estrous does may be required to actively seek potential mates due to low population density.

Key words: breeding, movements, *Odocoileus virginianus*, parturition, rut, white-tailed deer

Investigations of changes in seasonal home range size and the social behavior associated with parturition and breeding have yielded little information on the driving force behind daily movements of female white-tailed deer (Ozoga et al. 1982,

Holzenbein and Schwede 1989, Nixon et al. 1992, Bertrand et al. 1996). Decreases in home range size of females immediately prior to and following parturition have been observed in captive herds (Ozoga et al. 1982) and in moderate to high-density, free-ranging populations (Nixon et al. 1992, Schwede et al. 1993). Territory defense and the anti-social behavior associated with fawning have been attributed to the necessary formation of the mother-offspring bond (Lent 1974). Isolation and maternal aggression also may be vital for the protection of fawns from predators (Ozoga et al. 1982). Researchers have associated higher deer densities with small home ranges (Marchinton and Jeter 1967, Ellisor 1969, Marshall and Whittington 1969, Ozoga et al. 1982, Marchinton and Hirth 1984) and increased fawn mortality (Ozoga et al. 1982). In areas with overcrowding and fragmented habitat, doe home range size does not differ among seasons, probably due to a minimum home range size being reached (Bertrand et al. 1996, Kilpatrick and Spohr 2000). Bertrand et al. (1996) reported that parturition home range size increased in fawning seasons following a controlled reduction in deer herd density. In low-density deer populations in both northern (Fritzen 1992) and southern (Zultowsky 1992) Florida, home range sizes of lactating females decreased between parturition and weaning.

Female white-tailed deer breeding behavior may be affected by relative density of males (Ozoga and Verme 1975, Holzenbein and Schwede 1989, Labisky and Fritzen 1998). In populations with an abundance of males, does entering estrus restrict movements to core-use areas, perhaps to make their locations more predictable to prospective mates (Downing and McGinnes 1976, Ivey and Causey 1981, Holzenbein and Schwede 1989, Beier and McCullough 1990). In observations of penned does separated from males, Ozoga and Verme (1975) reported a marked increase in activity the night before females entered estrus. Other research by Holzenbein and Schwede (1989) suggested that does approaching the onset of estrus without a potential mate will switch from a passive breeding strategy to an active search mode. Correspondingly, Labisky and Fritzen (1998) reported that females in a low-density population with a relative scarcity of males used core areas less and increased movements from pre-rut to peak-rut. No studies to date have examined behavior of breeding females in a low-density population with an equal proportion of males.

To provide additional understanding of how demographic features of a herd affect reproductive behaviors, we investigated 24-h diel movements of female white-tailed deer relative to parturition and breeding in a low-density population with an even sex ratio on the Savannah River Site, near Aiken, South Carolina.

Study Area

Our study was conducted on the 80,267-ha SRS in Aiken, Barnwell, and Allendale counties, South Carolina. The SRS was a U.S. Department of Energy National Environmental Research Park located in the Upper Coastal Plain physiographic province (Imm and McLeod in press). The topography was gently rolling to flat with elevations ranging from 20–130 m. The SRS was 97% forested, with longleaf pine *(Pinus palustris)* and loblolly pine *(P. taeda)* dominating the canopy of uplands

(68%). Other major vegetation types were swamps and riparian bottomlands (22%) and upland hardwoods (7%) (Imm and McLeod in press).

In 1950, SRS was estimated to contain <24 deer (Johns and Kilgo in press). By 1965 the population rebounded and controlled dog hunting was instituted to reduce the incidence of deer-vehicle collisions. Controlled dog hunting has provided a safe, efficient means of maximizing hunter effort within areas targeted for deer population control (Novak et al. 1999). The U.S. Forest Service set annual population reduction goals to maintain a sitewide population of 4,000 deer with an even sex ratio.

Methods

We captured deer in rocket nets and by tranquilization with a dart gun (Dan-inject, Børkop, Denmark; Palmer Cap-chur Equipment, Douglasville, Georgia) from January 2001 to July 2002. We placed rocket nets on established food plots planted in seasonally desirable forage crops and baited them with whole kernel corn and trace mineralized salts. We immobilized deer captured in rocket nets with xylazine hydrochloride administered intramuscularly at 1 mg drug/kg estimated body weight. We loaded transmitter darts (Pneu Dart, Williamsport, Pennsylvania) with a 3-cc mixture of Telazol (500 mg in solution) and xylazine hydrochloride (180 mg). Deer were fitted with radiocollars (Advanced Telemetry Systems, Isanti, Minnesota), eartagged, and assigned an approximate age by tooth wear and replacement criteria (Severinghaus 1949). We reversed immobilization drugs with yohimbine hydrochloride (0.06 mg/kg intramuscularly). Animal handling procedures were approved by the University of Georgia Institutional Animal Care and Use Committee (No. A3437-01).

We used radio receivers (Advanced Telemetry Systems, Isanti, Minnesota; Communication Specialists, Orange, California) and three-element folding Yagi antennas to take bearings from geo-referenced telemetry stations. We triangulated deer locations using sequential bearings, taking <20 min to collect the three-seven bearings used to estimate the location of an individual deer (Nams and Boutin 1991). We located deer at 1-h intervals during 6–13 24-h diel monitoring sessions, separated by >24 hours, during each of the following periods: pre-parturition (9 May–31 May); post-parturition (1 June–12 July); pre-rut (14 September–29 October); rut (30 October–28 November); and post-rut (29 November–23 December). Monitoring periods were based on conception dates previously described for white-tailed deer on SRS (Rhodes et al. 1991) and a 200-day gestation length (Haugen 1959, Verme 1965). Rhodes et al. (1991) reported that >70% of adult and yearling female white-tailed deer on SRS conceive within 13 November $\pm$ 15 days. Average transmitter to receiver distance during this study was 470.42 m (SE = 420.16 m). Mean angular telemetry error was 8.3° (SE = 0.80) as determined by estimating bearings ($N = 50$) to 10 test transmitters placed at known locations in the study area. We used LOCATE2 (Nams 1990) to estimate deer locations.

We entered deer locations into a spreadsheet and imported them into ArcView 3.2 (Environmental Systems Research Institute, Redlands, California) as point themes. We calculated 95% kernel home range, with the Animal Movements exten-

sion (Hooge and Eichenlaub 1997) in ArcView to estimate diel and period home ranges. We quantified diel home range (ha) as the area used during a 24-h period. We derived monitoring period home ranges for each deer from all locations collected during 24-h monitoring sessions in that period. We also used point locations to calculate diel rate of travel and distance between extreme diel locations. Diel rate of travel (m/h) was the sum of successive distances traveled between sequential radio locations divided by number of hours a deer was monitored. Distance between extreme diel locations (m) was the greatest distance between any two radio locations obtained for a deer during a diel monitoring period (Labisky and Fritzen 1998).

Within the regular SRS managed hunt schedule, each radiocollared doe was subjected to 1 or 2 3-h to 4-h hunts, which occurred on 28 September, 30 October, 4 December, and 7 December 2002. We excluded the post-rut movements of two does harvested during managed hunts on 4 December and 7 December 2002 from analyses. We removed all 24-h monitoring sessions that included a managed hunt, and considered hunting to have negligible effects on female movements during other diel periods (D'Angelo et al. 2003). We used the Dixon outlier detection test (Sokal and Rohlf 1995) to identify and remove deviant 24-h monitoring periods from paired analyses among monitoring periods. We then calculated mean diel home range, mean diel rate of travel, and mean distance between extreme diel locations for each doe during each of the spring and fall monitoring periods. We used the Kolmogorov-Smirnov two-sample test ($P < 0.05$; Sokal and Rohlf 1995) to test for normality among mean measures of mobility for periods paired for comparison including pre-parturition and post-parturition, pre-rut and post-rut, pre-rut and rut, and rut and post-rut. We used a paired-sample t-test ($P < 0.05$) to compare mean measures of mobility for each female among periods that did not differ significantly in frequency distributions. We used the Wilcoxon rank sum test ($P < 0.05$; Sokal and Rohlf 1995) to compare mean measures of mobility among periods with non-normal distributions.

Results

We captured 13 females, including 12 adults and 1 yearling. We located 11 adult and 1 yearling female white-tailed deer a total of 4,367 times (pre-parturition = 1,355, post-parturition = 3,012) during 221 24-h diel spring monitoring sessions (pre-parturition = 73, post-parturition = 148). Diel home range generally encompassed one-third to one-half of the period home range (Table 1). Pre-parturition measures were greater than post-parturition for diel home range size (t-test: $t_{11} = -5.05$, $P < 0.001$), distance between extreme diel locations ($t_{11} = -25$, $P = 0.004$), and diel rate of travel ($t_{11} = -5.21$, $P < 0.001$; Table 2). We visually confirmed fawning in 10 of 11 adult does during the post-parturition period. We did not observe one adult and the yearling. However, we assumed that both fawned because nearly 100% of adult females (Johns and Kilgo in press) and 40% of fawns (Rhodes et al. 1991) conceive on SRS.

During the fall sampling period, we located 12 adult and 1 yearling female deer 6,141 times (pre-rut = 2,583, rut = 1,930, post-rut = 1,628) during 288 24-h diel peri-

Table 1.   Mean diel home range size (ha) and mean period home range size for female white-tailed deer during pre-parturition (9 May–31 May), post-parturition (1 June–12 July), pre-rut (14 September–29 October), rut (30 October–28 November), and post-rut (29 November–23 December) on the Savannah River Site, South Carolina, 9 May–23 December 2002.

	N	Diel home range	Period home range
Pre-parturition	12	98.77 (42.78)	236.83 (241.69)
Post-parturition	12	60.43 (32.69)	206.03 (202.35)
Pre-rut	13	67.78 (30.28)	208.14 (161.04)
Rut	13	79.43 (52.01)	177.89 (130.68)
Post-rut	11	47.47 (16.02)	108.76 (47.26)

Table 2.   Mean percent change in diel home range size (%), distance between extreme diel radio locations (%), and diel rate of travel (%), for female white-tailed deer from pre-parturition (9 May–31 May) to post-parturition (1 June–12 July), pre-rut (14 September–29 October) to post-rut (29 November–23 December), pre-rut to rut (30 October–28 November), and rut to post-rut on the Savannah River Site, South Carolina, 9 May–23 December 2002.

	N	Diel home range	Distance between extreme locations	Diel rate of travel
Pre-parturition to post-parturition	12	–38.17 (18.69)[a]	–17.04 (21.50)[a]	–18.20 (11.70)[a]
Pre-rut to post-rut	11	–24.76 (28.22)[a]	–20.12 (16.31)[b]	–21.34 (10.10)[b]
Pre-rut to rut	13	22.30 (81.81)	2.40 (24.44)	–0.23 (15.97)
Rut to post-rut	11	–28.35 (32.45)[a]	–20.85 (16.90)[b]	–20.89 (12.98)[b]

a. Difference significant at $P < 0.05$ according to paired-sample t-test.

b. Difference significant at $P < 0.05$ according to Wilcoxon rank sum test.

ods (pre-rut = 123, rut = 92, post-rut = 73). We detected no difference between pre-rut and rut for diel home range size ($t_{12} = 0.89$, $P = 0.20$), distance between extreme diel locations ($t_{12} = 0.23$, $P = 0.410$), and diel rate of travel ($t_{12} = –0.20$, $P = 0.42$). We observed decreases in diel home range size ($t_{10} = –2.69$, $P = 0.01$), distance between extreme diel locations (Wilcoxon rank sum test: T = 4, $P < 0.001$), and diel rate of travel (T = 0, $P < 0.001$) from pre-rut to post-rut. Likewise, female movements during rut exceeded those during post-rut for diel home range size ($t_{10} = –2.07$, $P = 0.03$), distance between extreme diel locations (T = 2, $P < 0.001$), and diel rate of travel (T = 0, $P < 0.001$). Those 24-h periods removed as outliers for fall monitoring periods were characteristic of substantial increases in female mobility, suggesting breeding excursions related to estrus (Fig. 1). We identified 12 such periods for eight does from 26 September to 6 December 2002. During periods of fall excursion, does averaged a 360% (SE = 231.07, N = 12) increase in diel home range size, a 163%
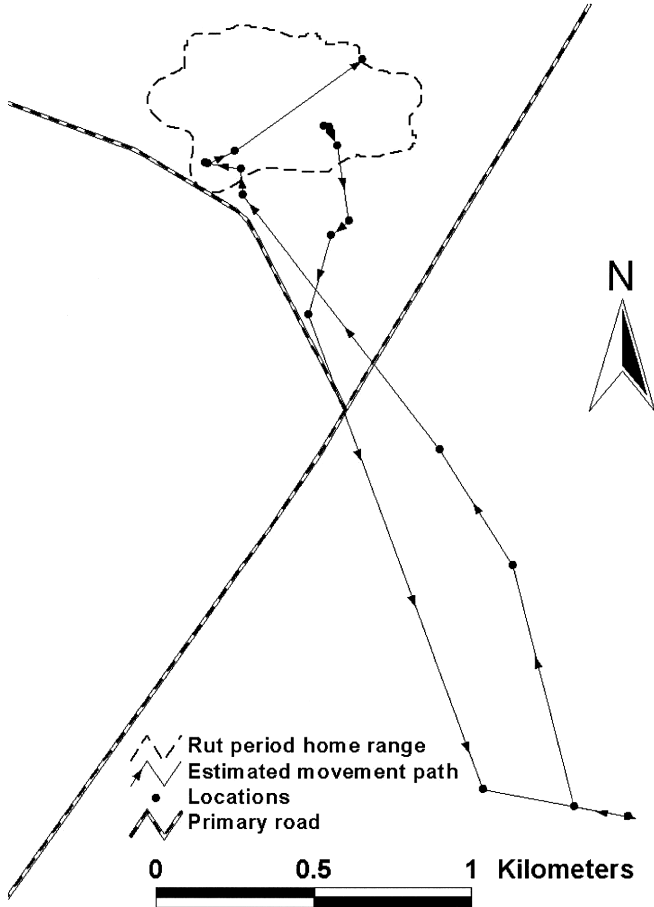
Figure 1. Estimated movements of one female white-tailed deer on Savannah River Site, South Carolina during a 24-h period, which included an excursion on 18 November 2002.

(SE = 124.76, N = 12) increase in distance between extreme diel locations, and a 75% (SE = 38.47, N = 12) increase in diel rate of travel. Three does exhibited two periods of excursion each, separated by 50, 50, and 48 days, respectively.

Discussion

Lactating female white-tailed deer minimize mobility after fawning in the low-density population measured in our study, as has been reported for herds with other demographic conditions. Ozoga et al. (1982) found that a sudden, lasting decline in home range size coincided with female parturition date in a crowded, supplemental-

ly fed, captive herd. Correspondingly, Bertrand et al. (1996) confirmed that females decreased home range size and frequency of social affiliations relative to parturition in a high-density, captive herd. However, parturition home range size for does in that herd was greater in a fawning season following a controlled reduction in herd density, but still less than that of non-lactating does. The degree to which parturient females reduce mobility may be due to intraspecific competition for territory to promote the formation of a mother-offspring bond. Schwede et al. (1993) observed isolation of lactating does from previous offspring and other parturient females through aggression. Nixon et al. (1992) proposed a kinship theory with deer recognizing relatives and behaving toward them within limits dictated by their degree of relatedness.

The decrease in female mobility during the post-parturition period also may be explained as a return to "normal" movement levels following exaggerated mobility during the pre-parturition period, perhaps indicating pre-partum restlessness. Although our monitoring scheme did not provide information on the 24-h diel movements of females during the entire year, the pre-parturition period home range size exceeded those measures during the other periods studied. In an 826-ha enclosure, Downing and McGinnes (1976) observed abnormal long distance movements in does preparing to bear their first fawns. Vore and Schmidt (2001) reported that during the four days before giving birth, maternal elk *(Cervus elaphus)* in a non-migratory herd increased daily movements more than two-fold and then decreased mobility by 80% during the four days post-calving.

Our data suggest that despite a near equal sex ratio, estrous does may be required to actively seek potential mates due to low population density. These findings correspond with those of Labisky and Fritzen (1998) for females in a low-density population in which males were limited. Similarly, Holzenbein and Schwede (1989) observed a <24-h, long-distance excursion by a female immediately prior to her tending by an adult male at the end of rut after most breeding activity had ceased. Beier and McCullough (1990) reported six occasions on which radio-tagged does increased daily activity by >80% during rut on the George Reserve, Michigan, where males were culled in greater numbers than females. Sawyer (1981) determined that temporary movements of three does to the outside or periphery of their home ranges coincided with conception.

Excluding excursions, indices of female movements did not differ throughout pre-rut and rut. Seasonal variations related to weather or food availability may have caused reduced movements during post-rut (Marchinton and Hirth 1984). Active searching for a mate by females likely explains daily increases in mobility. However, an alternative explanation may be forced movements resulting from harassment by males after onset of physiological heat before the doe's peak estrous receptivity (Verme and Ullrey 1984). Holzenbein and Schwede (1989) found that females maintained predictable locations within their core areas prior to formation of tending bonds and then expanded their range over a period of several days in attempts to avoid the courting male.

Miller et al. (1995) suggested that shorter breeding seasons in deer herds may be

related to balanced sex ratios and increased numbers of mature bucks because fewer does remain unbred during their first or subsequent estrous cycles. Such a sex and age structure exists for the SRS deer population (Johns and Kilgo in press). However, we observed multiple excursions by at least three radiocollared does, suggesting repeated estrous cycling, possibly related to a low overall density of deer. Protracted breeding seasons negatively impact fawn survival, doe productivity (Jacobsen and Guynn 1995), and antler development (Shea et al. 1992) in white-tailed deer. Thus, in the absence of an acceptable male within her home range, a doe may alter movements preceding or during estrus to maximize the probability of encountering a male.

Management Implications

Increasingly, deer management programs emphasize greater harvest of does in attempts to balance sex ratios and maintain deer populations at densities well below carrying capacity (Hamilton et al. 1995). Benefits resulting from such harvest regimes typically include greater forage availability and a sustainable harvest of trophy males (McCullough 1984, Jenks et al. 2002). Yet, the interaction between deer demographics and social behavior may be of greater importance to the fitness of individual deer and the maximum expression of desirable physical characteristics (i.e., large antler size and body mass). Maintaining populations at moderate densities and near even sex ratios promoting the efficient breeding of does during their first estrous cycle by mature bucks, ensures minimal energy loss by breeding males and females. Likewise, a shortened rut requires breeding deer to move less, thus decreasing their susceptibility to mortality factors outside of the intended management scheme.

Ackowledgments

Literature Cited

Beier, P. and D. R. McCullough. 1990. Factors influencing white-tailed deer activity patterns and habitat use. Wildlife Monographs 109.

Bertrand, M. R., A. J. DeNicola, S. R. Beissinger, and R. K. Swihart. 1996. Effects of parturition on home ranges and social affiliations of female white-tailed deer. Journal of Wildlife Management 60:899–909.

D'Angelo, G. J., J. C. Kilgo, C. E. Comer, C. D. Drennan, D. A. Osborn, and K. V. Miller. 2003. Effects of controlled dog hunting on the movements of female white-tailed deer. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 57:317–325.

Downing, R. L. and B. S. McGinnes. 1976. Movement patterns of white-tailed deer in a Virginia enclosure. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 29:454–459.

Ellisor, J. E. 1969. Mobility of white-tailed deer in south Texas. Journal of Wildlife Management 33:220–222.

Fritzen, D. E. 1992. Behavior of adult female white-tailed deer in a low-density population in pinelands of northern Florida. Thesis, University of Florida, Gainesville, Florida.

Hamilton, J., W. M. Knox, and D. C. Guynn. 1995. How Quality Deer Management Works. *In* K. V. Miller and R. L. Marchinton, editors. Quality whitetails: the why and how of quality deer management. Stackpole Books, Mechanicsburg, Pennsylvania.

Haugen, A. O. 1959. Breeding records of captive white-tailed deer in Alabama. Journal of Mammalogy 40:108–113.

Holzenbein, S., and G. Schwede. 1989. Activity and movements of female white-tailed deer during the rut. Journal of Wildlife Management 53:219–223.

Hooge, P. N. and B. Eichenlaub. 1997. Animal movement extension to ArcView version 1.1. Alaska Biological Science Center, U.S. Geological Survey, Anchorage.

Imm, D. W. and K. W. McLeod. In Press. Plant communities. *In* J. C. Kilgo and J. I. Blake, editors. Ecology and management of a forested landscape. Island Press, Washington, D.C.

Ivey, T. L. and M. K. Causey. 1981. Movements and activity patterns of female white-tailed deer during the rut. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 34:266–271.

Jacobsen, H. A. and D. C. Guynn. 1995. A Primer. *In* K. V. Miller and R. L. Marchinton, editors. Quality whitetails: the why and how of quality deer management. Stackpole Books, Mechanicsburg, Pennsylvania.

Jenks, J. A., W. P. Smith, and C. S. DePerno. 2002. Maximum sustained yield harvest versus trophy management. Journal of Wildlife Management 66:528–535.

Johns, P. E. and J. C. Kilgo. In Press. White-tailed deer. *In* J. C. Kilgo and J. I. Blake, editors. Ecology and management of a forested landscape. Island Press, Washington, DC.

Kilpatrick, H. J. and S. M. Spohr. 2000. Spatial and temporal use of a suburban landscape by female white-tailed deer. Wildlife Society Bulletin 28:1023–1029.

Labisky, R. F. and D. E. Fritzen. 1998. Spatial mobility of female white-tailed deer in a low-density population. Journal of Wildlife Management 62:1329–1334.

Lent, P. C. 1974. Mother-infant relations in ungulates. *In* V. Geist and F. Walther, editors. The behaviour of ungulates and its relation to management, Volume 1. IUCN, Morges, Switzerland.

Marchinton, R. L. and L. K. Jeter. 1967. Telemetric study of deer movement ecology in the southeast. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 20:189–206.

_____ and D. H. Hirth. 1984. Behavior. *In* L. K. Halls, editor. White-tailed Deer: ecology and management. Stackpole Books, Harrisburg, Pennsylvania.

Marshall, A. D. and R. W. Whittington. 1969. A telemetric study of deer home ranges and behavior of deer during managed hunts. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 22:30–46.

McCullough, D. R. 1984. Lessons from the George Reserve, Michigan. *In* L. K. Halls, editor.

White-tailed deer: ecology and management. Stackpole Books, Harrisburg,Pennsylvania.

Miller, K. V., R. L. Marchinton, and J. J. Ozoga. 1995. Deer Sociobiology. *In* K. V. Miller and R. L. Marchinton, editors. Quality whitetails: the why and how of quality deer management. Stackpole Books, Mechanicsburg, Pennsylvania.

Nams, V. O. 1990. LOCATE2 user's guide. Pacer Computer Software, Truro, Nova Scotia, Canada.

_____ and S. Boutin. 1991. What is wrong with error polygons? Journal of Wildlife Management 55:172–176.

Nixon, C. M., L. P. Hansen, P. A. Brewer, and J. E. Chelsvig. 1992. Stability of white-tailed doe parturition ranges on a refuge in east-central Illinois. Canadian Journal of Zoology 70:968–973.

Novak, J. M., P. E. Johns, and M. H. Smith. 1999. Current status of the SRS deer herd: demographic health and the attainment of management objectives. Ten-year summary report. Savannah River Ecology Laboratory, Aiken, South Carolina.

Ozoga, J. J., L. J. Verme. 1975. Activity patterns of white-tailed deer during estrus. Journal of Wildlife Management 39:679–683.

_____, L. J. Verme, and C. S. Bienz. 1982. Parturition behavior and territoriality in white-tailed deer: impacts on neonatal mortality. Journal of Wildlife Management 46:1–11.

Rhodes, O. E., J. M. Novak, M. H. Smith, and P. E. Johns. 1991. Frequency distribution of conception dates in a white-tailed deer herd. Acta Theriologica 36:131–140.

Sawyer, T. G. 1981. Behavior of female white-tailed deer with emphasis on pheromonal communication. Thesis, University of Georgia, Athens.

Severinghaus, C. W. 1949. Tooth development and wear as criteria of age in white-tailed deer. Journal of Wildlife Management 13:195–216.

Schwede, G., H. Hendrichs, and W. McShea. 1993. Social and spatial organization of female white-tailed deer, *Odocoileus virginianus*, during the fawning period. Animal Behavior 45:1007–1017.

Shea, S. M., T. A. Breault, and M. L. Richardson. 1992. Relationship of birth date and physical development of yearling white-tailed deer in Florida. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 46:159–166.

Sokal, R. R. and F. J. Rohlf. 1995. Biometry. Third edition. W. H. Freeman, New York, New York.

Verme, L. J. 1965. Reproduction studies on penned white-tailed deer. Journal of Wildlife Management 29:74–79.

_____ and D. E. Ullrey. 1984. Physiology and Nutrition. *In* L. K. Halls, editor. White-tailed deer: ecology and management. Stackpole Books, Harrisburg, Pennsylvania.

Vore, J. M. and E. M. Schmidt. 2001. Movements of female elk during calving season in northwest Montana. Journal of Wildlife Management 29:720–725.

Zultowsky, J. M. 1992. Behavioral and spatial ecology of female white-tailed deer in the Everglades ecosystem. Thesis, University of Florida, Gainesville.