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Abstract: Annual variation in breeding success among female white-tailed deer (*Odocoileus virginianus*) fawns on the Savannah River Plant (1967 to 1985) was determined from direct counts of pregnancy in spring-collected fawn females and evidence of lactation and measurements of udder thickness in fall-harvested 1.5-year-olds. Percent lactation in 1.5-year-old females collected during September and October gave the best estimate of fawn breeding in the previous year. The overall mean fawn breeding estimate from September and October was 41%, and the yearly variation in fawn breeding was significant. An estimate of the average yearly contribution to recruitment was 43 fetuses per 100 fawn females.

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Assessing reproductive performance is an important part of comprehensive deer management programs. Recruitment partially determines the number of deer available for harvest in future years (McCullough 1979). Doe fawns commonly breed in the Savannah River Plant (SRP) herd in South Carolina (Urbston 1967, 1976), and may add substantially to recruitment because the population's age structure is skewed toward younger animals (Scribner et al. 1985). However, because fawns tend to breed later than older females (Johns et al. 1977), breeding frequency is difficult to determine based upon hunter harvested animals. To avoid this problem, fawn females can be harvested after the regular hunting season, necropsied, and inspected for the presence or absence of fetuses. This approach is often objectionable to hunters, and is certainly time and labor intensive. The presence of milk in teats of (1.5-year-old) females can also be used to indicate fawn breeding in the previous year.

Our primary objective was to determine if udder condition of yearling females is indicative of prior pregnancy. We hypothesized that udder thickness of hunter harvested yearlings can be used as such an indicator. Milk should be present only in females whose udders have developed to nurse offspring, and the ratio of nursing versus nonnursing yearling females should reflect the percentage of females breeding as fawns, provided that most offspring survive long enough to allow detection of lactation during the fall harvest. A secondary objective was to summarize data for fawn breeding success on the SRP during the last 19 years and to determine the average annual contribution of the fawn age class to recruitment.

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Methods

Deer were collected (shot) on the SRP during spring collections (from 1 February to 31 May 1985) and were inspected at check stations during either sex fall deer hunts from 26 October to 29 December 1985. Check station data collected between 1 September and 31 December were also available from fall deer hunts during 1967–1984. Fawn females (N = 17) were collected in spring and were weighed and examined for presence of embryos. Date of kill, body weight, and presence or absence of milk in the teats were recorded for each yearling female (N = 130) collected. Udder thickness was measured directly under the nipple of a randomly-chosen rear teat using metric calipers. All females were aged according to Severinghaus (1949).

Two estimates of fawn breeding success were generated in each year based upon the percentage of yearling females that had milk in at least 1 teat in September and October (Period 1) or September through December (Period 2). Incidence of fawn breeding was also determined using the frequency distribution of udder thickness among yearlings, categorized as either visibly-lactating or nonlactating. The distributions of udder thicknesses from each category were tested for normality; means and variances were used to plot predicted normal distributions for each group and to estimate the point of intersection. The theoretical and observed distribution of udder thicknesses were analyzed to estimate number of females assigned to the nonlactating group which, though not visibly lactating at time of collection, should have been classified as lactators. The difference calculated between the expected and observed number of lactators in the range of the distribution defined by the second standard deviation below the mean, provides an estimate of the number of lactating deer misclassified as nonlactators.

Estimates of fawn breeding success were compared using Chi-square contingency analysis. Body weights of fawns, that were classified as breeders, were compared to those of nonbreeders using a *t*-test. Statistical significance was set at $P \leqslant 0.05$.

Results

Fifty-three percent of the 1985 spring-collected fawns were pregnant (Table 1), which is identical to the estimate based upon yearling lactation rates in October 1985 (Period 1, Table 2). However, when all yearling females collected in the period October through December 1985 were used to calculate percent fawn breeding the estimate was 31% (Period 2, Table 2). This 22% difference in estimates between the spring collections and Period 2 of 1985 was not significant ($\chi^2 = 3.33$, 1 df, $P = 0.068$).

Our estimate of fawn breeding, using the distribution of yearling doe udder thickness in October through December 1985, was 31%. Overlaid plots for predicted and observed distributions of lactating versus nonlactating yearlings are shown in Figure 1. Neither observed distribution differed ($P > 0.05$) from normal (lactators $N = 38$, skewness $= -0.36$, $t = 0.91$, kurtosis $= 0.32$, $t = -0.40$; nonlactators $N = 71$, skewness $= 0.05$, $t = 0.17$; kurtosis $= -1.09$, $t = 1.87$). Two nonlactators were reclassified to lactators as a result of the calculated difference in expected and observed distributions of udder thickness of lactating females. The corrected estimate (32%) of fawn breeding, using the frequency distribution of udder depths from lactating 1.5-year-old females, was not different ($P > 0.05$) from the estimate generated from percent lactation in the same females.

Percent lactation in 1.5-year-old females was used to make separate estimates of fawn breeding from Periods 1 and 2 in each year from 1966 to 1984 (Table 2).

Table 1. Percentage and whole body weights (kg, ±1 SE) of reproductive and nonreproductive female white-tailed deer killed in 1985. Evidence of pregnancy was presence of visible embryos in the fawns or milk in teats of yearlings.

Type of female	Category	Reproductive	Nonreproductive
Spring-collected	Percentage	53 ($N = 9$)	47 ($N = 8$)
Fawns	Mean body weight	76.22 ± 4.47[a]	69.75 ± 3.37[a]
Fall-collected	Percentage	31 ($N = 40$)	69 ($N = 90$)
1.5-year-old females	Mean body weight	89.55 ± 1.13[b]	98.82 ± 1.10[b]

[a] $t^1 = 1.16$, $P = 0.27$, df = 14.
[b] $t^1 = -2.07$, $P = 0.04$ using assumption of nonhomogeneous variances, df = 107.

Table 2. The number and percentage of lactating 1.5-year-old female white-tailed deer killed by hunters from 1967 to 1985 on the Savannah River Plant. Sequential values are indicative of the magnitude of fawn breeding in the preceeding year.

	Lactating 1.5-year-old females			
	September–October (Period 1)		September–December (Period 2)	
Year	*N*	% of sample	*N*	% of sample
1967	16	27	31	24
1968	15	68	44	51
1969	9	69	58	46
1970	13	52	38	37
1971	13	36	24	20
1972	4	21	23	28
1973	25	37	53	31
1974	10	31	21	23
1975	3	17	10	12
1976	24	60	45	42
1977	9	28	17	19
1978	8	21	23	25
1979	13	39	44	35
1980	12	53	35	36
1981	40	55	111	41
1982	37	43	73	29
1983	32	34	59	25
1984	3	23	25	22
1985	7	53	40	31
Mean		40.37[a]		30.37
SD		(16.218)		(10.057)

[a]The mean difference between fawn breeding estimates of Periods 1 and 2 was 10%.

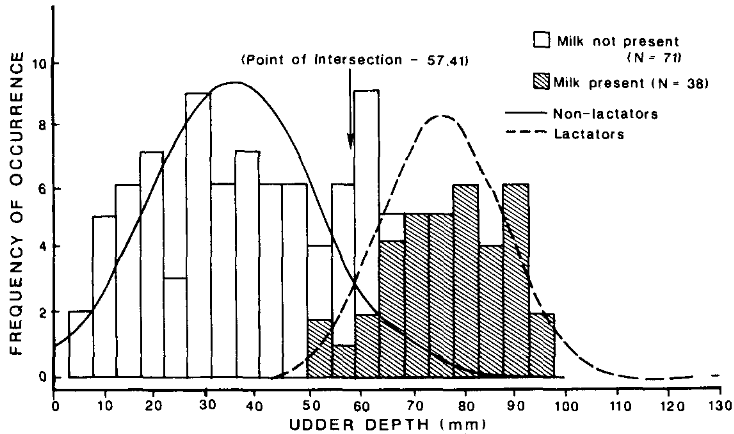

Figure 1. The observed and expected frequency distributions of lactating and nonlactating females with udders of different depths. Neither observed distribution differed ($P > 0.05$) from that predicted from a theoretical normal distribution.

Mean percent fawn breeding estimated in Period 1, during the 19-year period, was 40% while Period 2 was 30% (Table 2). Fawn breeding estimates, generated from Period 1, were higher than those of Period 2 with an average absolute difference over years of 10% more breeding fawns estimated from Period 1 (Table 2).

Annual fawn breeding estimates from the percent lactation in 1.5-year-old females from Period 1 are higher than those from percent lactation-based estimates from November through December ($t = 5.79$, $P < 0.001$). Fawn breeding estimates from Periods 1 and 2 are used in this study because in most management situations sample sizes of yearling females make these categories for the data more applicable. Yearly variation in fawn breeding estimates of both periods was also significant (Period 1: $\chi^2 = 52.7$, df = 18, $P < 0.001$; Period 2: $\chi^2 = 96.9$, df = 18, $P < 0.001$).

Body weights of lactating, 1.5-year-old females were different from those of nonlactators using data from Period 2 in 1985 (Table 1). However, body weights of pregnant spring-collected fawn females in 1985 were not different from those of nonpregnant fawn females.

Discussion

Estimates of fawn breeding, based on lactation in 1.5-year-old females in Period 2, 1985 (31%) and on the distribution of udder depths of these same females (32%) were not different. However, in 1985 each estimation method gave a lower percentage of fawn breeders than estimated for lactating females in Period 1 (53%) or in spring collected fawn females (53%). Although there are no differences among estimates for 1985, the trend of lower estimates in Period 2 than in Period 1 across years averaged 25%. Lower estimates for Period 2 suggest some potential bias in late fall data. Bias could be caused by early cessation of lactation and subsequent regression of the udder in the earliest breeding fawns because of weaning and/or the death of offspring of some fawn breeders. Our preferred estimate of SRP fawn breeding is percent lactation in 1.5-year-old females in Period 1. Period 1 estimates of fawn breeding was the same as that calculated from the spring collection of fawns. Data on lactating females can be obtained easily at check stations. It is a minimal estimate of fawn breeding, however, and may be biased by early weaning and offspring mortality.

All yearlings with greater udder thicknesses were lactating and none of the lactating females had unusually small udder measurements. The distribution of measurements of udder depth in yearlings adequately separated lactating and nonlactating females in all months. However, this estimate is subject to the same biases that affect the estimate based on lactating females in Period 2. Therefore, use of udder thickness in yearlings to estimate fawn breeding is not reasonable for managers because it provides no additional information.

Late fall estimates of fawn breeding could be biased if cessation of lactation and a subsequent regression of the udder occurred before data for the estimate were taken. The udder regression of a lactating female would occur after her offspring have weaned or died. The mean conception date for fawn breeders on the SRP is approximately 29 December (Johns et al. 1977). If a mean gestation of 200 days is assumed (Verme 1965), then the predicted mean birthdate for offspring of fawn breeders is 18 July. Nursing period of white-tailed deer offspring is in the range of 3–4 months (Scanlon et al. 1976; Scanlon and Urbston 1978). Therefore, it is likely that a number of fawn breeders who ceased lactation early were counted as non-breeders in the estimates that included data from the late fall. Because of the timing of breeding, it is likely that these early breeders are responsible for a substantial proportion of the mean annual difference of 25% (±19%) between estimates of fawn breeding in Periods 1 and 2.

Offspring mortality of fawn mothers may also be responsible for a portion of the observed 25% difference between the 2 periods. One possible source of fawn mortality on the SRP is that of fawn harvest during the fall hunting season. Offspring of fawn breeders may be harvested during the early portion of the hunting season and some yearlings taken late in the hunting season may be counted as non-lactators because of the regression of their udders after the loss of a fawn in this manner. Natural offspring mortality in fawn breeders also seems likely given the additional energy stress a young reproducing female must bear.

In fall, body weights of yearlings that did not breed as fawns (nonlactators) were higher and more variable than those that did breed (lactators) (Table 2). This difference may reflect energetic stresses placed on female fawns during pregnancy and lactation. In fall, fawns have only reached about 50% of their asymptotic body weights and energetic stresses are substantial in breeders, who must not only provide energy for daily maintenance costs but also provide for growth and reproduction (Chesser and Smith 1985). Fawn breeders divert less total energy to reproduction than do adults as evidenced by lower fetal numbers in fawns (1.06) than in adults (1.63) (Rhodes et al. 1985). Lactating yearlings also have lower levels of body fat than nonlactating females (Cothran et al. 1983). Thus, fawn reproduction may be constrained by resource availability and/or ability to partition resources into this process. Mortality of offspring from fawn females is probably a partial consequence of this constraint and inexperience.

The percentage of fawns that breed in any year as calculated from either Period 1 or 2 has varied over the past 19 years. Reproductive rates in the youngest females are the most sensitive to changes in resource availability (Verme 1969, Hesselton and Jackson 1974). Percent body fat data from the fall male fawns are available for the SRP deer herd from 1974 to 1978 (Johns et al. 1982). The percent body fat of male fawns in the fall should reflect the relative abundance of resources available to young deer prior to and during breeding. There was no correlation between percent body fat in male fawns (1974–1978) and the estimated percentage of female fawns breeding in the same year. This may suggest that there are no measurable environmental effects on percent fawn breeding on the SRP. There is also no correlation between percent fawn breeding over years and estimated density (Scribner et al. 1985).

An explanation for the observed variation in fawn breeding over years could be that our estimates of percent lactation in yearlings may be influenced by varying number of fawn offspring that survive each year. Some of the offspring of fawns are not physiologically capable of breeding in their first fall because of their late birth dates; therefore, they are counted in the following fall as nonlactating yearlings. The number of offspring of fawns that survive could partially be influenced by a number of factors. Therefore, differences in the number of breeding fawns and the varying impact of their offspring on future fawn breeding could be responsible for the observed annual variation.

After years of intensive harvest, the age structure of the deer herd on the SRP is skewed towards younger animals (Scribner et al. 1985). The mean age of females is 2 years; <16% of all females were >3.5 years. Therefore, it is critical for individuals to reproduce as soon as they are physiologically capable in order to maximize their fitness. Approximately 32% of all females are fawns in any year, and fluctuations in the percentages of fawn breeders affects herd productivity. Therefore, the percentage of fawns breeding must be estimated if annual recruitment is to be determined in the herd. Our best estimate over years of the average annual percentage of fawn breeders is 40%, with a mean litter size of 1.06 fetuses per fawn doe (Rhodes et al. 1985). This gives us a maximal estimate of 42.8 fetuses per 100 fawn females produced annually on the SRP. This is a considerable contribution to recruitment in the population and is approximately 11% of the total annual productivity for females of all ages (Rhodes et al. 1985).

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