Wildlife Session

Reproductive Characteristics of Female White-tailed Deer in Missouri

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Abstract: We measured reproductive parameters of 2,833 female white-tailed deer (*Odocoileus virginianus*) collected from 1978 to 1986 and 1989 to 1993 in 3 geographical regions of Missouri. Fawn pregnancy and fetal rates were lower ($P < 0.001$) than those of yearling and older does. Ozark region fawns had lower fetal rates than fawns from the Glaciated Plains region; no other regional differences were found. Fetal sex ratios approached 1:1 and were not influenced by year of collection, litter size, region, or age of doe. However, yearling and older does that conceived late in the annual breeding season produced a higher proportion ($P = 0.001$) of males than those conceiving earlier. Fawn does breed later in the fall than yearling or adult does, but there were no regional or annual effects on mean conception dates. Most (75%) yearling and adult breeding occurred during a 2-week period while 75% of fawn breeding covered 7 weeks. Our results showed little annual variation in fecundity during a 14-year period for yearling and adult does. Fawn reproductive rates were more variable, suggesting that periodic monitoring of fawn reproduction is warranted.

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Population modeling may serve as a valuable tool for guiding white-tailed deer harvest recommendations (Pojar 1981, Williams 1981). Models can be used to compare different harvest management scenarios and assist biologists with developing harvest recommendations (Pojar 1981). However, McCullough (1984) cautioned that the utility of accounting models is limited because they require detailed input data and difficult-to-measure linkages between age- and sex-specific reproductive and mortality rates. Accounting models are especially problematic in areas where density-dependent reproductive and mortality rates regularly operate or where winter mortality or disease outbreaks are difficult to predict or quantify. However, some white-tailed deer populations are located in areas associated with agriculture, where farming provides abundant food that can sustain deer numbers far above public tolerance levels. In these situations, population modeling may be simplified because mortality and reproductive rates may vary little. We determined reproductive characteristics of Missouri does from 1978 to 1986 and 1989 to 1993 to provide input for population models.

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Methods

We sampled 1,112 does from 1978 to 1986 (period 1) and 1,721 does from 1989 to 1993 (period 2). Does hit by vehicles provided the majority of the sample. Does shot on crop depredation permits, entangled in fences, and illegally taken supplemented the sample. We obtained samples from 3 Missouri natural divisions (Thom and Wilson 1980): the Glaciated Plains, Ozark Border, and Ozarks (Fig. 1). These 3 natural divisions represent the areas in Missouri with highest deer populations and harvests. We collected reproductive information from 1 February to 31 May each year because most Midwestern does conceive by the end of December with fetuses visible by 1 February (Roseberry and Klimstra 1970, Nixon 1971, Haugen 1975). However, analysis of the effects of sampling month on pregnancy and fetal rates indicated that pregnancy and fetal rates in February and May were lower than in March and April. During February, fetuses are small, and some cooperators may have missed small fetuses during necropsy. The lower pregnancy rates in May could have resulted from sampling postpartum does. Also, late-term fetuses may be expelled during a collision with a vehicle and thus missed during necropsy. Therefore, analyses of pregnancy and fetal rates were conducted only for does collected in March and April. We included data from all 4 months for analyses of fetus sex ratio and conception dates.

During period 1, Missouri was divided into thirds by arbitrary north-south lines for sampling purposes. Each year, 1 of these sections was sampled. Thus, each section was sampled once every 3 years. During period 2, sampling occurred statewide annually. During both periods, field staff eviscerated each deer and examined the uterus. When present, fetuses were sexed. During period 2, we determined fetus age from crown-rump measurements (Hamilton et al. 1985). We calculated conception dates for pregnant does by subtracting fetal age from the collection date. The primary incisors of each doe were extracted, placed in a self-addressed padded envelope and submitted to the Fish and Wildlife Research Center in Columbia, Missouri. Age breakdown was attained using cementum annuli analysis (Gilbert 1966) at Matson's

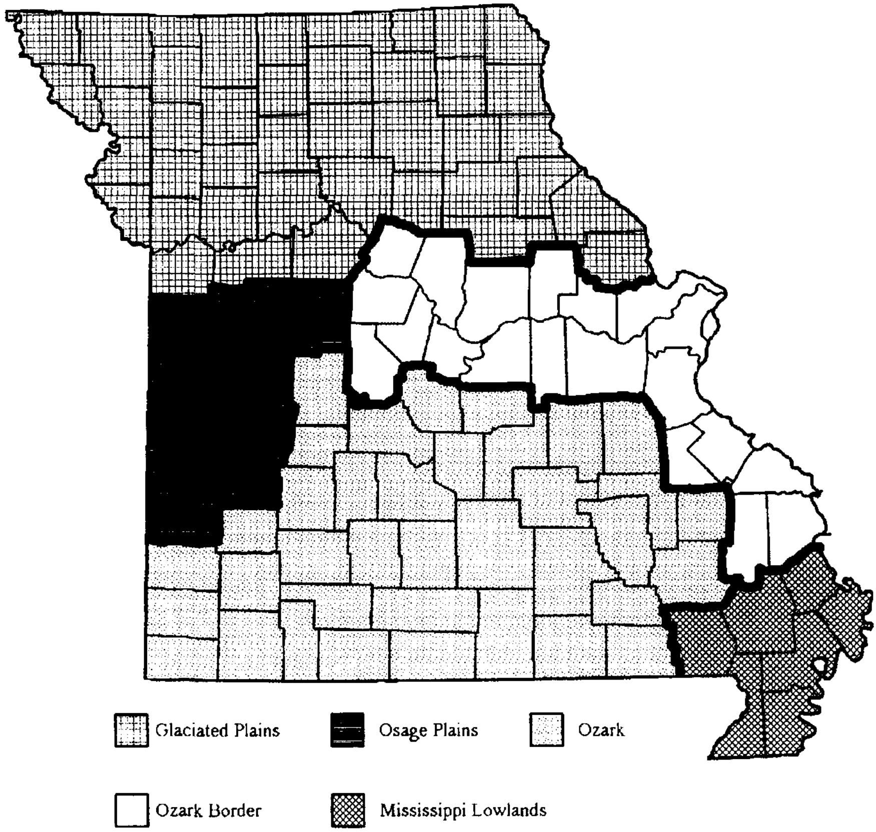

Figure 1. The Natural Divisions of Missouri showing study locations, the Glaciated Plains, Ozark Border, and Ozark study regions.

Laboratory (Milltown, Mont.). Each deer was classified as fawn (<1 year of age), yearling (≥1 year and <2 years), or adult (≥2 years). During period 2, for analysis of age effects on reproductive rates, actual ages in years were used. If teeth were not collected or were not in satisfactory condition for sectioning (12% of sample), tooth replacement and wear aging was used (Severinghaus 1949), but age class breakdown was limited to fawn, yearling, and adult. Deer for which no age could be determined were eliminated from the sample. We defined pregnancy rates as the percentage of the does sampled that were pregnant. Fetal rate was the number of fetuses per pregnant doe.

For most analyses, data from periods 1 and 2 were analyzed separately because sampling procedures differed. For period 1, fetuses were not measured, so date of conception could not be determined. Also, annual and regional statistical comparisons could not be made because of different sampling locations among years. Age differences in pregnancy rates and sex ratios were determined using χ^2 analysis. For period

2, we determined annual, regional, and age-specific differences in pregnancy rates and sex ratios using logistic model analysis and log-linear model analysis, respectively. To test the same effects on fetal rates and mean conception dates, we used 3-way analysis of variance with Bonferroni T tests to determine paired differences. A median test was used to compare sex ratios of fetuses conceived during different parts of the breeding season (early, 1 Oct–3 Nov; intermediate, 4 Nov–7 Dec; and late, 8 Dec–31 Jan). Statistical analyses were conducted using the Statistical Analysis System (SAS Inst. 1990). The α significance level was set at $P = 0.05$.

Results

Pregnancy Rates

During period 1, pregnancy rates varied among age classes ($X^2 = 242.09$, df = 2, $P < 0.001$) due primarily to lower fawn pregnancy rates compared with older does. Yearling pregnancy rates were consistently, but not significantly ($X^2 = 1.74$, df = 1, $P = 0.20$), lower than those of adult does (Table 1). Logistic model analysis revealed

Table 1. Pregnancy rates and fetal rates of deer collected in Missouri (F = does <1 year of age, Y = does ≥1 year and <2 years, and A = does ≥2 years).

Period	Age	*N*	% Pregnant	*N*[b]	Mean *N* of fetuses	SE	Does with 0,1,2, or 3 fetuses 0	1	2	3
				Glaciated Plains						
1978–1986	F	112	41.4	46	1.26	0.07	66	34	12	0
	Y	63	92.1	58	1.77	0.07	5	15	40	3[a]
	A	95	94.7	90	1.90	0.05	5	17	65	8
1989–1993	F	238	33.8	49	1.33	0.07	107	34	14	1
	Y	152	91.5	107	1.90	0.05	8	23	72	12
	A	197	92.9	165	1.97	0.05	14	34	102	29
				Ozark Border						
1978–1986	F	51	41.2	21	1.29	0.10	30	15	6	0
	Y	25	84.0	21	1.76	0.10	4	5	16	0
	A	35	97.1	34	1.82	0.10	1	9	22	3
1989–1993	F	92	28.3	19	1.32	0.11	51	13	6	0
	Y	59	94.9	48	1.81	0.08	2	12	33	3
	A	105	97.1	90	1.93	0.06	3	17	62	11
				Ozarks						
1978–1986	F	61	18.0	11	1.64	0.20	50	5	5	1
	Y	52	86.5	45	1.76	0.10	7	16	24	5
	A	94	88.3	83	1.88	0.05	11	15	63	5
1989–1993	F	109	21.1	16	1.31	0.16	65	12	3	1
	Y	65	86.2	43	1.79	0.08	7	11	30	2
	A	183	94.0	146	1.90	0.04	11	23	114	9

[a]One of these does had 4 fetuses.

[b]*N* may be smaller than expected based on percent pregnant because does that were lactating or for which fetal counts were incomplete were not included in the sample.

that during period 2 the only significant term was age. Fawns were significantly less likely to breed than yearlings or adults ($P < 0.0001$). No regional, annual, or interaction effects were found although fawn reproductive rates were consistently lower in the Ozarks than in the Glaciated Plains (Table 1).

Pregnancy rates of does grouped into progressively older age classes indicated consistent but not significant ($X^2 = 5.36$, df = 3, $P = 0.16$) increases until 8 years of age with subsequent decreases in older age classes (Table 2).

Fetal Rates

During period 2, fetal rates varied by age ($F = 417.71$; df = 2, 950; $P < 0.001$), tended to vary by region ($F = 2.68$; df = 2, 950; $P = 0.06$) but did not vary by year ($F = 0.82$; df = 4, 938; $P > 0.50$). There were no significant interactions among variables. Fawn fetal rates were lower than those of yearlings or adults. Although yearling fetal rates were consistently lower than those of adults, the differences were not significant (Table 1). As with pregnancy rates, fetal rates of pregnant does in extended age classes increased through 8 years of age with a small drop in does ≥9 years old. The regional differences in fetal rates were mostly a result of higher rates for yearling and adult does in the Glaciated Plains than in the Ozarks (Table 1).

Sex Ratios

Fetal sex ratios approached 50:50 during period 1 (51% males) and period 2 (50% males). For period 1, we found no effects of litter size ($X^2 = 3.68$, df = 2, $P = 0.16$) or age class ($X^2 = 6.55$, df = 4, $P = 0.16$). During period 2, log-linear analysis indicated that the proportion of fetuses that were male was dependent on age of the doe ($P = 0.047$) but not on the region or year. Older does were more likely to have male fawns than younger does (Table 3); however, these differences were small. The tendency for an age effect in period 2 resulted from a preponderance of male fetuses produced by does ≥9 years old.

Date of conception had a significant effect on fetal sex ratios ($X^2 = 13.72$, df = 2, $P = 0.001$). Yearling and adult does that conceived late in the annual breeding season had a higher proportion of male fetuses (55.4%, $N = 91$) than those breeding during the intermediate (51.5%, $N = 786$) or early (44.7%, $N = 124$) periods.

Table 2. Effects of age on pregnancy and fetal rates of does sampled in Missouri from 1989–1993.

Age (Years)	*N*	% Pregnant	*N*	Mean *N* of fetuses/ pregnant doe	SE
<1.0	297	27.3	81	1.33	0.06
≥1.0<2.0	211	91.9	194	1.85	0.04
≥2.0<5.0	288	93.8	270	1.91	0.03
≥5.0<9.0	80	96.3	77	2.01	0.07
≥9.0	41	85.4	35	1.83	0.09

Table 3. Effect of age on sex of fetuses of white-tailed deer in Missouri.

	1978–1986[a]		1989–1993	
Age (Years)	*N*	% Male	*N*	% Male
<1.0	127	57.5	189	48.2
≥1.0<2.0	246	46.8	527	53.7
≥2.0<5.0	419	51.3	779	47.5
≥5.0<9.0	—	—	119	50.2
≥9.0	—	—	82	59.8

[a]Separated only into 3 age classes, <1 year, ≥1 year <2 years, and ≥3 years.

Conception Dates

Doe age affected timing of conception (F = 110.52; df = 2, 1004; P < 0.001). Regional and annual effects were not significant (F = 0.13; df = 2, 1004; P = 0.88 and F = 0.52; df = 4, 1004; P = 0.72, respectively). No significant interactions were noted among main effects. The mean date of conception for fawns (10 Dec, SE = 2.2 days, N = 160) was later than that of yearlings (18 Nov, SE = 1.0 days, N = 317) and adults (16 Nov, SE = 0.6 days, N = 634). Mean conception dates for yearlings and adults were not different. Considering only 2 age classes (fawn and yearling-adult), and pooling across region and year, 75% of yearling and adult conceptions occurred within a 2-week period during the middle of November (Fig. 2). Fawn conception dates were less concentrated than those of the older does, with 75% of the breeding extending over a 7-week period (Fig. 2).

Discussion

Pregnancy and fetal rates generally were consistent with rates observed in other Midwestern states with comparable habitat (Roseberry and Klimstra 1970, Nixon 1971, Haugen 1975, Harder 1980, Grubaugh 1983, Stoll and Parker 1986, McCaffery and Ashbrenner 1992). Reproductive rates of fawns, however, were lower in the agricultural Glaciated Plains compared with other agricultural parts of the Midwest (Haugen 1975, Grubaugh 1983, McCaffery and Ashbrenner 1992). Also, we have observed a decline in fawn reproductive rates in the Glaciated Plains since deer were reintroduced in the 1950s. Dunkeson (1958) reported that approximately 70% of fawns in northern Missouri bred during 1951–1958, compared to 41% during 1978–1986 and 34% during 1989–1993. We found no change in fetal rates during these periods. Evidence from deer harvests also is consistent with reduced fawn pregnancy rates. Fawn to doe ratios in harvested deer in Missouri declined from an average of 1.69 in 1960–1965 to 1.51 in 1970–1975, 1.13 in 1980–1985, and 0.95 in 1990–1994 (L. P. Hansen unpubl. data). Hunter selectivity, increases in fawn predators—especially the coyote (*Canis latrans*) (Hamilton 1995), and reduced fawn fecundity may have been factors in this decline.

Declines in fawn pregnancy rates occurred concurrent with rapid increases in

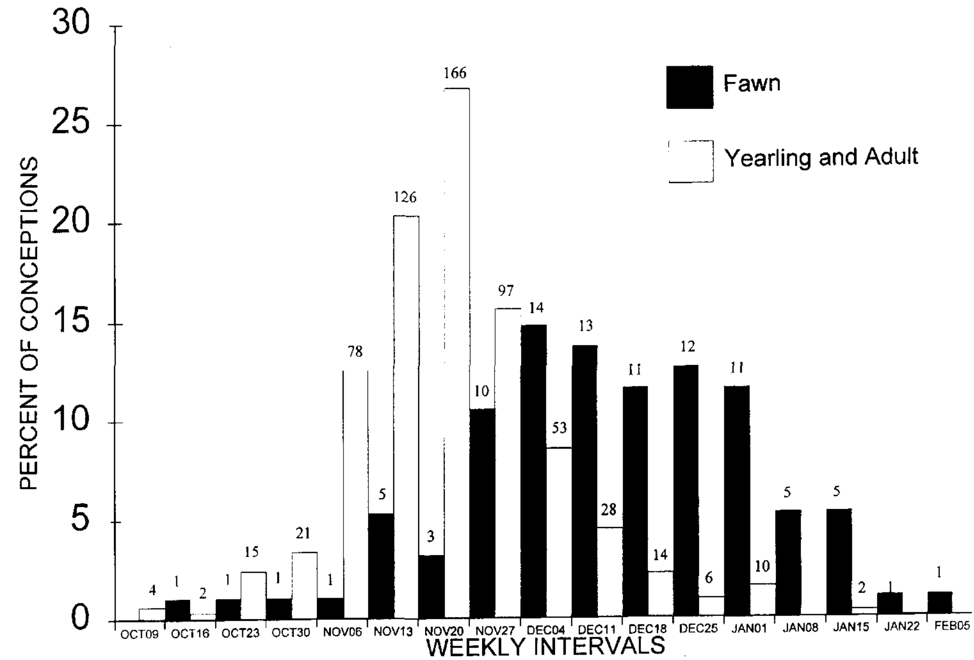

Figure 2. Distribution of conception dates for fawn and yearling-adult deer collected from 1989–1993 in Missouri.

deer populations in Missouri. Deer harvests doubled from 1970 to 1980 and more than tripled from 1980 to 1990 (L. P. Hansen unpubl. data). The number of reported roadkilled deer also doubled during each of these time increments (L. P. Hansen unpubl. data). Density increases that occurred simultaneously with reduced fawn fecundity suggested that a density-dependent relationship could exist (Verme 1991). Verme (1991) attributed a decline in pregnancy rates to density-dependent biosocial factors to which fawns were most sensitive. In the Glaciated Plains of Missouri and much of the agricultural Midwest, deer densities relative to cover increase markedly during the fall following crop harvest (Nixon et al. 1991). This concentrating effect occurs after part of the yearling and adult does have bred. Crop harvest is almost invariably complete and deer are highly concentrated when fawns breed. As deer populations have increased, so has this concentrating effect. Fawns in the agricultural areas may be more socially stressed with lower breeding rates as a result.

Availability of males for breeding could also potentially affect fawn pregnancy rates (Gruver et al. 1984, Jacobson et al. 1979). However, the proportion of yearlings in the antlered harvest—an indication of harvest rates—averaged 60% between 1990 and 1994 compared to 70% in the previous 2 decades, suggesting that availability of males for breeding was not a cause in the decline of fawn pregnancy rates.

Age affected pregnancy and fetal rates more than any other variable we tested in this study. Fawn reproductive rates were much lower than those of deer in older age classes. Reproductive rates increased slightly each year until around 9 years and then showed slight declines. However, these differences were small and deer older than 15 years continued to be productive, as observed by Masters and Mathews (1990).

Fawns showed regional differences in fecundity, although these differences generally were small. During the fall, fawns have attained only about 50% of the adult weight (Chesser and Smith 1987) and have less body fat than adults (Johns et al. 1984). These low fat levels and high energy requirements for growth may produce higher sensitivity to resource availability or biosocial effects (Verme 1967, Rhodes et al. 1985). The Ozarks, where fawn reproductive rates were lowest, include heavily forested habitats with few agricultural crops. Deer in this region are probably more dependent on browse and variable mast crops. Mast abundance has been shown to affect demography of deer in other areas (Feldhamer et al. 1989, Wentworth et al. 1990, 1992) and may explain lower fawn reproductive rates. Nevertheless, in the Missouri Ozarks, fawn reproduction varied little, suggesting that food either was not highly limiting or consistently depressed fawn reproduction. In northern Missouri, where forest cover is limited and intensive agriculture occurs in many areas, food resources are higher quality, which may explain regional differences in fawn fecundity.

Later conception dates in fawns than yearlings or adults in Missouri is similar to that observed in other areas (Nixon 1971, Ozoga and Verme 1982). Verme and Ozoga (1987) contended that there was a critical fat/lean biomass ratio that regulated the onset of puberty in fawns. Fawns direct energy toward growth during the breeding season rather than fat deposition (Johns et al. 1984). Lower body fat may limit fawn reproduction as a result and push conception dates later than those of adults.

Management Implications

Deer population models are data demanding and not practical when reproductive and survival rates are variable and unpredictable. The results of this study suggest that reproductive rates for yearling and adult does in Missouri during a 14-year study period were constant regionally and temporally. This observation makes modeling more practical because constant rates can be input and continual monitoring of regional yearling and adult reproductive rates may not be necessary. A long-term trend toward decreasing reproductive rates of fawn does suggest that fawn breeding may be more sensitive to densities or some other environmental factor (McCullough 1984). Fawn reproductive rates, therefore, may better indicate the relationship between current population size and maximum sustained yield, as suggested by Downing and Guynn (1985). Also, changes in fawn reproductive rates can have important impacts on population dynamics. Population simulations indicate deer populations are most sensitive to birth rates and the proportion of female fawns at birth (Medin 1976), with age at first reproduction an important variable affecting population change (Cole 1954). These results suggest that regular monitoring of fawn fecundity may be required to determine changes for model input and to aid in understanding status of deer populations.

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