Relationship of Mast, Ovarian Activity, Recruitment and Deer Condition in Northeast Georgia

Kent E. Kammermeyer, *Georgia Department of Natural Resources, 2150 Dawsonville Hwy., Gainesville, GA 30501*

David M. Carlock, *Georgia Department of Natural Resources, 2150 Dawsonville Hwy., Gainesville, GA 30501*

Abstract: We collected reproductive tracts from female white-tailed deer *(Odocoileus virginianus)* along with mast indices, deer condition data, and population parameters for a 20-year period in northeastern Georgia. The objectives were to determine what factors influenced reproduction and if ovulation incidence or mast abundance could be used to predict recruitment rate the following year. Percentage of does bred before 1 December and adult doe ovulation incidence were both associated with mast abundance. Higher ovulation incidence of adult does coincided with early breeding. Recruitment rate was not correlated with mast supply, ovulation incidence, or late breeding of any doe age classes from the previous year. The only real value of ovarian analyses was the identification of late breeding in years of acorn scarcity, which also coincided with poorer condition and reproductive effort. Because late breeding can be predicted by mast scarcity, ovarian analysis data is non-essential compared to condition and mast data. Although not significant on an annual basis, ovulation incidence averaged 27% higher than the corresponding recruitment rate for the 20-year period. How much of this difference represents fetal or fawn mortality, hunter selection, or other factors was not clear.

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There have been few reported attempts to establish a relationship between ovulation incidence or mast abundance and subsequent recruitment rate in white-tailed deer. Fawn mortality is seldom known in wild populations and has varied greatly in penned studies (Verme 1962, 1963; Murphy and Coates 1966).

White-tailed deer ovarian analyses are conducted by universities, state and federal agencies, and private landowners to monitor fecundity, reproductive events, and timing of conception (Jacobson et al. 1979, Bullock et al. 1995). Relationships between ovulation incidence, parturition frequency, and recruitment rate are rarely known. The procedure can provide valuable information on peak of breeding, ovulation, and fertilization rates by age class, but these data may be expensive to collect. Special hunts, often scheduled late in the hunting season, are necessary. Adequate sample sizes are almost always a problem because samples are divided into 3 or more doe age classes for analyses. For this reason, long-term data sets based on ovarian analyses for the same deer herd are rare.

For the period 1976–1996, we collected reproductive tracts in all but 2 years on the 6,880-ha Lake Russell Wildlife Management Area (WMA) in Northeastern Georgia. For the same period, we conducted a hard-mast survey (Whitehead 1969) and collected data on age structure, condition, and population parameters from hunter-harvested deer (Kammermeyer and Painter 1978, Kammermeyer 1990). These data provided a rare opportunity to accomplish 3 objectives: (1) identify factors which might influence reproductive and recruitment rates (2) determine if ovulation incidence or mast could be used to predict recruitment rate the following year, and (3) verify that reproductive effort in Northeastern Georgia was similar to that reported for the Deer Camp population model developed in New York (Moen et al. 1986).

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Methods

Study Area

Lake Russell WMA is located on Chattahoochee National Forest in the upper Piedmont physiographic region of northeast Georgia. The area has been under lease from the U. S. Forest Service as a state-operated WMA since the early 1950s. The following habitat types comprised the area: upland hardwood (13%), cove hardwood (3%), yellow pine (50%), mixed pine hardwood (15%), clearcuts (0–10 years old) (<19%), and food plots (<0.4%). In the past 8 years, the percentage of clearcuts has increased at the expense of mature pine and hardwood.

Data Collection

We required checking of harvested deer and collected the following data: sex, age, eviscerated weight, antler diameter, antler beam length, and number of points. In January, does were brought to the check station whole, where uteri and ovaries were collected. Reproductive tracts were tagged and fixed in 10% buffered formalin solution until they were examined for corpora lutea and fetuses as described by Cheatum (1949). Samples from all does ≥1.5 years old (adult) were collected. Samples from younger does (≤0.5 years) were collected when they exhibited uterine swelling or ovarian follicles, but fawn breeding was rare.

We sectioned ovaries longitudinally at 1-mm intervals with a scalpel and inspected macroscopically for occurrence of corpora lutea (CL), corpora rubra, and

Table 1. Mast index, breeding parameters and condition indicators for Lake Russell Wildlife Management Area in northeastern Georgia, 1976–1996.

Year	Mast index	Recruit-ment	Ovulation incidence: Yearling (1.5 year-old) (N)	Ovulation incidence: Adult (>1.5 year-old) (N)	% All does bred before Dec.1	Adult doe weights (kg)	Yearling buck antler beam (cm)	Harvest /km2
1976		1.10	1.50 (4)	2.05 (21)	96	34.1	14.9	13.5
1977	5.10	0.60				32.3	14.5	10.6
1978	2.92	0.90	1.00 (7)	1.85 (13)	50	31.4	16.8	19.4
1979	4.13	0.78	1.17 (10)	1.75 (46)		34.5	15.2	40.9
1980	2.64	0.75	1.00 (6)	1.40 (25)	28	29.0	13.5	24.3
1981	2.79	0.81	1.13 (8)	1.81 (32)	73	31.6	12.2	23.8
1982	2.62	0.96	1.38 (8)	1.83 (29)	43	31.2	15.5	31.1
1983	0.75	0.89	1.00 (7)	1.63 (24)	35	31.3	17.0	24.3
1984	3.66	1.00	1.10 (10)	1.88 (24)	63	31.5	10.4	25.4
1985	4.67	0.60	1.00 (5)	1.95 (23)	67	31.9	10.9	24.6
1986	4.68	0.97				30.7	15.5	27.2
1987	0.78	1.01	1.13 (8)	1.25 (20)	29	30.0	17.5	31.3
1988	5.88	0.68	1.20 (5)	1.79 (19)	72	32.5	10.9	28.7
1989	2.85	1.01	1.13 (8)	1.78 (23)	23	29.5	16.3	30.8
1990	5.99	0.57	1.00 (4)	1.65 (19)	78	33.0	10.9	33.2
1991	2.11	0.60	1.20 (5)	1.74 (19)	46	31.3	15.5	29.3
1992	1.90	0.76	1.00 (6)	1.57 (14)	20	30.9	12.7	33.9
1993	1.66	0.90	1.00 (5)	1.27 (15)	25	29.6	11.7	24.8
1994	5.75	0.79	1.00 (2)	1.79 (24)	82	34.3	11.7	25.5
1995	2.19	1.13	1.60 (5)	1.57 (7)	8	32.6	17.3	25.7
1996	3.83	0.74	1.33 (6)	1.78 (23)	38	33.6	12.2	31.6
Mean	3.35	0.84	1.15(119)	1.70(420)	48.7	31.7	14.0	26.7

follicles (Cheatum 1949). Does with fully leutinized CL and no uterine swelling were backdated 10 days to a breeding date (Jacobson et al. 1979). CL with uterine swelling, but no visible fetuses were backdated to 20–28 days. Fetuses <10 mm were aged at 28 days (Severinghaus and Cheatum 1956) and those >10 mm were aged according to the characteristics described by Armstrong (1950) and Hamilton et al. (1985). Does were separated into 3 age classes: 0.5 years old, 1.5 year old, and ≥2.5 year old. Percentage of does in breeding condition before 1 December was calculated along with ovulation incidence ($\bar{x}$ number of corpora lutea for does with CL), and fertilization rate (N of fetuses/pregnant doe divided by number of CL/pregnant doe) (Cheatum 1949).

Standard condition data were collected from all deer. Ages were estimated based on tooth wear and replacement (Severinghaus 1949). Deer harvest varied from 110 to 420 (average 275); however, most of the variation occurred in the first 4 years with the hunt schedule very stable for the last 17 years (Table 1). Harvest/km^2 was calculated along with recruitment (N of fawns per adult doe in the harvest). Regulations and harvest restrictions have not changed appreciably since 1979. We used 3 population models: population reconstruction (Downing 1980), Lang and Wood (1976), and deer camp (Moen et al. 1986) to determine prehunt population estimates for Lake Russell, which ranged from 15 to 23 deer/km^2 over the 20-year period.

Mast Surveys

Mast surveys were patterned after those described by Whitehead (1969) in Tennessee. A 6-km route was established through representative oak-dominated habitat with stops made at 0.6 km intervals. Oak crowns were scanned with binoculars at each stop to determine percentage of crowns bearing acorns, percentage of twigs bearing acorns and average number of acorns/twig. Each tree was rated on a scale of 0–10 and a minimum of 75 trees were sampled and divided into 3 groups: (white oak *(Quercus alba, Q. stellata),* chestnut oak *(Q. prinus),* and red oak *(Q. rubra, Q. coccinea, Q. velutina, Q. falcata, Q. marilandica).* Most of the same trees (with dbh of 30–60 cm) were surveyed annually at 0.6 km intervals on the same 6 km route. We combined all groups for analysis, to yield 1 mast value/year for the whole area.

Data Analyses

Correlation coefficients *(r)* were determined for 9 variables including year, mast index, recruitment, ovulation rate of yearling and adult does, percentage of does bred before 1 December by age class, eviscerated weights of adult does, antler beam length of yearling bucks, and total harvest/km^2. Four correlation analyses were performed: (1) analysis with all variables compared in the same year (2) mast abundance in year 1 compared with all other variables in year 2 (3) all variables in year 1 versus recruitment in year 2 and (4) all variables in year 1 versus percentage does bred before 1 December in year 2. Selected variables with greater *r* values were further tested by regression analysis to determine an R^2 value.

Results and Discussion

Ovulation incidence of adult does was correlated with percentage does bred before 1 December (r=0.66, P=0.003), but ovulation incidence of yearling does was not (r=0.05, P=0.856). In years when mature does bred earlier, they also produced more corpora lutea, thereby increasing potential for production of more fetuses (Verme 1967). Next, regression analyses showed percentage of does bred before December 1

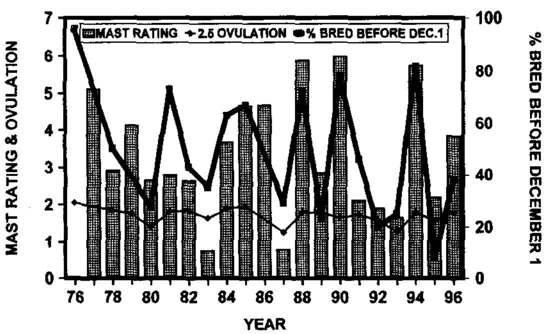

Figure 1. Relationship of combined ovulation incidence and recruitment on Lake Russell Wildlife Management Area in northeastern Georgia. Percentage difference averaged 27% over 20 years.

(R^2=.77, P=0.0001) and adult doe ovulation incidence (R^2=0.55, P=0.018) were both associated with mast abundance, as mast scarcity appeared to be associated with low fecundity and late breeding (Table 1 and Fig. 1). Ovulation incidence of yearling does was not correlated with mast supply (r=0.10, P=0.70), probably because of small sample sizes (only 5–10 yearling does/year) and the relatively poor nutrition in a mast-driven system causing CL/yearling doe to frequently "bottom out" on the 1.00 minimum (Table 1).

The association between adult does and mast varied from 82% of does bred before 1 December with a mast rating of 5.75, to only 8% of does bred by the same date when the mast rating was 2.19. In 1976, 1 year before the mast survey was initiated, 96% of does were bred before 1 December. We documented that adult doe body weight was associated with mast supply (R^2=0.36, P=0.005) which we believe was a major factor affecting the estrous cycle. In years of mast failure (mast index <2.00) and associated low body weights, it took longer for does to reach the level of condition necessary to begin estrous activity (Verme 1965, 1967). Moreover, yearling buck antler beam length was correlated with mast in the previous year (R^2=0.53, P =0.001). Based on the above analyses, it appears that mast abundance was a significant factor influencing both deer condition and ovulation on Lake Russell WMA. Mast scarcity was correlated with late breeding and reduced fecundity.

The relationship between recruitment rate in year 2 and the previous year's ovulation incidence (Fig. 2) was not significant for adult does (R^2=0.003, P=0.81) or the combined yearling and adult doe classes (r=0.095, P=0.705). Many other factors subsequent to ovulation incidence probably influenced recruitment rate, such as fertilization frequency, and fetal and fawn mortality which may vary annually (Verme 1962, 1963) and are difficult or impossible to detect in free-ranging deer herds (Downing 1980). Also, hunters tend to harvest does rather than fawns when given the choice, but this hunter bias remains much more constant annually in a given area than does summer fawn mortality (Moen et al. 1986).

For the 20-year period, the average weighted difference between ovulation incidence and recruitment rate ranged from 0.75 to 0.03 and averaged 0.32 (overall ovulation incidence of 1.12 compared with average recruitment rate of 0.82). This

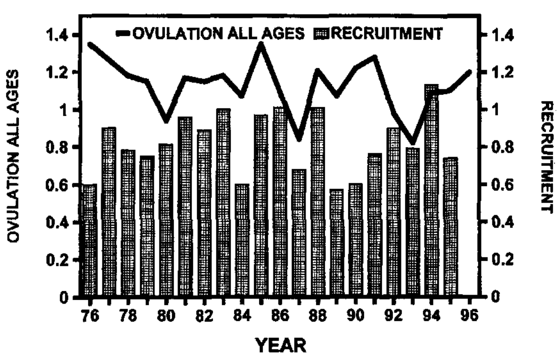

Figure 2. Effect of mast supply on adult doe ovulation incidence and percentage of does bred before 1 December on Lake Russell Wildlife Management Area in northeastern Georgia.

difference of 27% could likely be explained by fetal and fawn mortality or less likely by changes in hunter bias, changes in hunting regulations, hunter density, and weather. Fetal mortality rates of 10% and fawn mortality rates of 15% to 30% are commonly reported in the literature (Murphy and Coates 1966, Verme 1967, O'Pezio 1978).

Recruitment was not correlated with mast in the previous year (r=0.239, P≤0.31). Data from another study conducted in the northeastern Georgia mountains indicate that poor mast crops can impact deer body condition and numbers for at least 2 cohorts, those born in the same year as poor mast and those born the year after (Wentworth et al. 1992). One explanation may be due to an inherent observer bias in the mast survey since observers changed 3 times during the study. Also, acorn failures are buffered somewhat at Lake Russell WMA by greater occurrence of honeysuckle *(Lonicera japonica)*, greenbriar (*Smilax* sp.), food plots, and clearcuts. Consequently, failures may not impact recruitment to an extent seen in the mountains. In Michigan, Verme (1962) showed a close relationship between maternal nutrition and neonatal mortality. Neonatal mortality can be a highly variable, confounding factor impacting recruitment and only partially affected by mast from the previous fall. Good nutrition during the final third of gestation is a significant factor in productivity (Verme and Ullrey 1984).

Based on our data, the greatest value of ovarian analysis appears to be identification of late breeding in years of acorn scarcity, which also coincides with poorer condition and poorer reproductive effort (recruitment and antler beam length also were correlated [r=0.47, P=0.06]). The impact of late breeding associated with mast failures is also difficult to evaluate. Late breeding can possibly impact fawn survival or ultimate recruitment, but it also could impact future condition and reproduction which is keyed to body weights of does in autumn.

Another value of ovarian analyses is its use as a variable in deer population models. It can be used to cross-check and adjust the deer camp model. Antler beam diameter in that model drives reproduction. Data used to develop the deer camp model relied on antler and reproductive data from New York, but the same equations may not apply to other deer herds. A comparison of ovarian analysis and antler beam diameters between our deer herd and those in deer camp revealed a 1.70 ovulation incidence for adult does in January in Georgia, versus a 1.52 parturition frequency at birth for deer camp. Because of late breeding and does with CL but no matching fetus, we could not use fertilization rate in further analysis. In our study, the average difference was 11% over the 20-year period. This could easily be explained by fertilization rate and fetal mortality (Robinette et al. 1955, Ransom 1967). Thus, our data from Lake Russell were comparable to that used in the deer camp model. In addition, population estimates for Lake Russell from the Lang and Wood model (1976) agree closely with those of deer camp and also suggest that the recruitment rate used in deer camp are reasonable estimates.

Finally, we have demonstrated that poor mast supply was associated with late breeding at Lake Russell WMA. Since it appears that late breeding can be predicted by mast supply on this area, a mast survey conducted every year can be an important predictive tool for lower ovulation and late breeding, but not for recruitment. It also appears that while ovarian analyses can be a valuable condition indicator, it may not be a necessary management tool on areas where other condition indices and mast data are available. This is especially true if ovulation incidence cannot be used to predict recruitment rate. It is obviously preferable to use parturition frequency or fawn mortality as a predictor of recruitment, but these data are rarely available for free-ranging deer populations.

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