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Title: NATALITY OF BLACK-TAILED DEER IN MCDONALD STATE FOREST

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Natality of black-tailed deer in McDonald State Forest was determined by examination of 147 reproductive tracts. Yearlings collected from November of 1968 to May of 1970 had an average of 0.79 corpora lutea per doe, and adults 1.76 corpora lutea per doe. Yearlings collected during the spring in 1969 and 1970 had an average of 0.88 fetuses per doe and adults an average of 1.61 fetuses per doe. No fawn had either a fetus or a corpus luteum. The peak of breeding as established from ovarian examination in the fall occurred from November 1 to November 16 during both years of study.

Deer collected after a severe winter in 1968-1969 had an index of condition based on kidney fat significantly lower than after the winter of 1969-1970. The rate of ovulation and number of fetuses per doe during the more severe winter were lower than during the milder winter, but the differences were not statistically significant.

Frequency of dates on which female black-tailed deer apparently bred in 1969 and 1970 as established by estimating the duration of embryonic development and counting backwards from the date the deer was collected differed between 1969 and 1970. Examination of ovaries collected in October and November established that there was no difference between years in the timing of ovulation. The difference was believed due to the reduced condition of the does and resulting reduced growth of fetuses following the severe winter of 1968-1969. Information from life tables constructed by determining age of animals harvested by hunters revealed a population slightly above the point of optimum yield.

Natality of Black-tailed Deer in McDonald State Forest

by

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INTRODUCTION

The primary purpose of this study was to estimate natality (the number of new individuals per unit of time per unit of population [Odum, 1959]) of the population of black-tailed deer (Odocoileus hemionus columbianus) inhabiting McDonald State Forest in Benton County, Oregon, near Corvallis, during 1969 and 1970. An opportunity to compare natality and indices of physical condition between years with contrasting weather conditions existed when abnormally high snowfall occurred in the winter of 1968-1969 and almost no snowfall in the winter of 1969-1970. Thus, an estimate of natality and presentation of information on physical condition of the population relative to weather factors were possible.

Black-tailed deer hunting has been allowed on a permit basis in McDonald Forest since 1954. Each hunter was required to sign in and out of the Forest each day during the weekends when hunting was permitted. Each successful hunter was required to submit the harvested animal for inspection. All animals harvested were examined, weighed, and measured. An average of 16.5 deer per square mile has been harvested annually since 1954 with an average expenditure of 144 hunter days of effort per square mile during each of the 6- or 8-day hunting seasons. The hunting pressures and rates of harvest were higher than recorded for any other population of black-tailed deer in Oregon. This study represents a portion of a continuing investigation to measure the impact of the harvest on the population in McDonald Forest.

DESCRIPTION OF THE STUDY AREA

McDonald State Forest (including Paul Dunn Forest) includes 12,772 acres of forested hills in the Coast Range approximately 7 miles north of Corvallis, Oregon, and is under the administration of the School of Forestry, Oregon State University. Most of the area is between 500 and 1,400 feet above sea level; maximum elevation is 2,170 feet above sea level.

McDonald Forest is in the "*Tsuga heterophylla*" vegetative zone described by Franklin and Dyrness (1969). The predominant community type is *Pseudotsuga menziesii*/*Holodiscus discolor*. The predominant soil type is "Red Hill" (Gartz 1954), which occurs over much of the Coast Range. The stages of plant succession range from areas recently logged by clearcutting to areas covered by subclimax vegetation. Eighty-four percent of the Forest has an overstory of vegetation more than 30 years old.

The climate is normally mild (U.S. Department of Commerce 1969). Rainfall averages approximately 40 inches annually, and periodic summer drought is expected. Average temperature during January, the coldest month, is 39.4°F. Days with measurable amounts of snowfall in the mid-Willamette Valley average 3 to 4 per year. Depth of snow on the ground rarely exceeds 2 or 3 inches at lower elevations, and snow usually melts in 1 or 2 days.

Differences in Weather Between Years of Study

Precipitation during December and January of both years exceeded the normal values (Table 1). Moisture received during December 1968 was 220 percent of normal, one of the highest on record. Precipitation received during January 1970 established a new record for a January at the Corvallis State College (sic) Weather Station (U.S. Department of Commerce 1969 and 1970). The average temperature was below normal from December 1968, through February 1969 (Table 1). January 1969 had 490 percent more snow than normal. Colder temperatures, unusual amounts of snow, and duration of snow cover during the winter of 1968-1969 contrasted with the more mild winter of 1969-1970.

Table 1. Snowfall, precipitation, and mean temperature for December through February during study period as recorded by the Corvallis recording station. (Normals for months are in parentheses.)

Period	Snowfall (inches)		Precipitation (inches)		Temperature (^{o}F)	
December 1968	6.3	(0.4)	14.47	(6.57)	38.2	(41.0)
December 1969	0.0		11.59		41.4	
January 1969	24.0	(4.9)	9.35	(6.30)	34.4	(39.4)
January 1970	trace		15.51		41.0	
February 1969	0.5	(0.8)	4.27	(4.79)	39.2	(42.9)
February 1970	0.0		5.97		44.9	

METHODS

Collection of Data

Persons hunting in McDonald Forest were provided with a plastic bag and an illustration of the reproductive tract of female deer and were asked to submit tracts for examination from deer that they had killed. Sixteen complete tracts were obtained during October 1968; 40 tracts were obtained during November 1968, and 40 during November 1969. Hunting of antlerless deer was not permitted during October 1969, so 11 does were collected from McDonald Forest to provide a sample for comparison with the previous year.

Twenty does were collected from March to May in 1969 and in 1970, providing 40 reproductive tracts for examination during the period of gestation. Deer were located at night with the aid of spotlights and shot with a rifle. After collection of biological data, carcasses were donated to charitable organizations designated by the Oregon State Game Commission.

Determination of Age Distribution

The lower mandible was removed from each deer brought to the checking station, except infrequently when a hunter objected to the procedure. The jaws were marked, cleaned, and used to separate the animals into three categories -- fawn, yearling, and adult --

according to tooth replacement (Moreland 1952). Jaws of adults were separated into categories by degree of wear on the teeth and assigned to age classes (Moreland 1952).

Age was determined from replacement of teeth and the relative amount of wear, although this method offers opportunity for variability (Erickson et al. 1970). Counting annuli in dental cementum was found by Connally et al. (1969) to be unreliable for some coastal black-tailed deer. Thus, I believe that determining age from the relative amount of wear on the teeth of adults was justified for the purposes of this study.

Ovarian Analysis

Ovaries were stored in a 10 percent solution of formalin. Later they were sliced with razor blades into sections approximately 1 mm. thick and examined macroscopically for the presence of corpora lutea and corpora albicantia (Cheatum 1949).

Fetal Measurements

The length of each fetus was measured from crown to rump or forehead to rump as appropriate and weighed to the nearest 0.1 mg. Duration of gestation was estimated by comparing length and weight with appropriate growth curves established for mule deer fetuses (Hudson and Browman 1959). Growth curves representing black-tailed deer fetuses of known development were not available. Ommundsen and Cowan (1970) provided information that mule deer fetuses are larger than blacktail fetuses at the same stage of development. Application of the curves of Hudson and Browman (1959) probably would result in under-estimating the actual duration of development of blacktail fetuses. Because length of the fetus provided the older estimate of prenatal age in all cases except two, all prenatal ages were estimated from length. Approximate dates of breeding were determined by subtracting the estimated prenatal age of the fetus from the date of collection.

Determination of Physical Condition

Both kidneys, with accompanying deposits of fat, and one femur were obtained from each deer collected during gestation in an effort to appraise the effect of the more severe winter in 1968-1969 on the physical condition of the deer and to determine possible effects on natality.

One index of condition was obtained from the ratio of the weight of fat deposited around the kidneys to the weight of the kidneys (Riney 1955). Other indices of condition were obtained from bone marrow collected from femurs. Each femur collected was struck lightly with a hammer until the bone was splintered. The cylinder of marrow near the center of the long axis of the bone was removed and rated on a three-point scale for color and a three-point scale for texture (Riney 1955). Color and texture ratings were combined to yield the "visual estimate" of fat content. The consistency of a 2.5-inch section of the marrow was tested by observing the percentage compression of the marrow under its own weight (Greer 1968).

Estimation of Confidence Limits

The formula $L(\mu) = \bar{x} \pm t(.05)\sqrt{\frac{s^2}{n}}$ (Snedecor and Cochran 1956;76) was used to estimate confidence limits provided in the tables.

RESULTS

Corpora Lutea per Doe

Only 25 percent of the deer collected during October of 1968 and 1969 had corpora lutea (Table 2). However, 91 percent of the deer collected during November had already ovulated. Because of the significant difference in ovulation rates of deer collected in October and November ($\chi^2 = 40.13$; $P < 0.005$; d.f. = 1), combining data from ovaries collected during October with information obtained in November would have caused a pronounced under-estimation of the actual rate of ovulation. Therefore, only ovaries collected during November were used in determining the rate of ovulation in the fall. No significant difference ($\chi^2 = 0.14$; $P > 0.93$; d.f. = 1) occurred between years in the rate of ovulation of deer collected during November; therefore, data collected in November 1968 and 1969 were combined.

The average number of corpora lutea per yearling doe during November and spring periods of collection was 0.79 ± 0.25. The ovulation rate for adults was 1.76 ± 0.14. The rate of ovulation for all does of reproductive age was 1.53 ± 0.32. No corpora lutea were found in ovaries collected from fawns (Table 3).

Table 2. Adult female black-tailed deer grouped according to presence or absence of corpora lutea at time of collection of deer from McDonald State Forest in the fall of 1968 and 1969. (Calculated expected frequencies for χ^2 test are in parentheses.)

	October	November
Corpora lutea present	6 (17.5)	58 (46.5)
Corpora lutea absent	18 (6.5)	6 (17.5)

Table 3. Average number of corpora lutea per doe (with 95 percent confidence limits) from deer collected in McDonald State Forest. (Sample sizes in parentheses.)

Period of Collection	Fawns	Yearlings	Adults
November 1968	0.00 (8)	0.89 $\pm$ 0.47 (9)	1.74 $\pm$ 0.30 (23)
Spring 1969	0.00 (2)	0.67 $\pm$ 0.54 (6)	1.75 $\pm$ 0.48 (12)
November 1969	0.00 (8)	0.57 $\pm$ 0.49 (7)	1.76 $\pm$ 0.21 (25)
Spring 1970	0.00 (2)	1.50 $\pm$ 6.35 (2)	1.81 $\pm$ 0.35 (16)

Corpora Albicantia per Doe

An average of 0.71 $\pm$ 0.25 corpora albicantia per doe was found among does which had been yearlings during the previous breeding season (Table 4). The number of corpora albicantia per adult doe was 1.46 $\pm$ 0.19. Corpora albicantia per doe for yearlings and adults combined averaged 1.29 $\pm$ 0.59. Counts of corpora albicantia per doe obtained during the spring from samples of the population were lower than corpora lutea counts obtained the previous fall (Tables 3 and 4).

Table 4. Average number of corpora albicantia per doe (with 95 percent confidence limits) from deer collected in McDonald State Forest. (Sample sizes in parentheses.)

Period of Collection		Fawns	Yearlings	Adults
November	1968	0.00 (16)	0.50 ± 0.58 (6)	1.75 ± 0.19 (24)
Spring	1969	0.00 (6)	0.00 (1)	1.36 ± 0.81 (11)
November	1969	0.00 (9)	0.80 ± 0.56 (10)	1.52 ± 0.29 (23)
Spring	1970	0.00 (2)	1.00 ± 0.00 (4)	0.83 ± 0.60 (12)

Fetuses per Doe

Yearling does were carrying an average of 0.87 ± 0.53 fetuses during the spring (Table 5). Adult does averaged 1.61 ± 0.24 fetuses per doe. The average number of fetuses per doe for all females of reproductive age collected during the prenatal period was 1.44 ± 0.24.

Table 5. Average number of fetuses per doe (with 95 percent confidence limits) from deer collected in McDonald State Forest. (Sample sizes in parentheses.)

Period of Collection	Fawns	Yearlings	Adults
1969	0.00 (2)	0.67 ± 0.54 (6)	1.50 ± 0.43 (12)
1970	0.00 (2)	1.50 ± 6.35 (2)	1.69 ± 0.32 (16)
1969 and 1970	0.00 (4)	0.87 ± 0.53 (8)	1.61 ± 0.24 (28)

Percent Pregnancy

The rate of pregnancy among the 18 yearling and adult deer collected during the prenatal period each year was 94.5 percent. One non-pregnant, adult doe was collected each year. In 1969, the non-pregnant doe was in age class VII. There was no corpus luteum in either ovary. The ovaries contained four corpora albicantia, two dark orange and two lighter orange in color. This variation in pigmentation could occur with the loss of embryos early in the gestation period, as represented by the darker pair, and retention of two corpora albicantia from the previous year, or with twins during each of two previous years. The uterus contained no evidence of embryo or fetal remnants.

The non-pregnant doe in 1970 was in age class IV. There was no evidence of previous ovarian activity. The entire reproductive tract was similar to a fawn's; the ovaries and uterus were small and undeveloped. This doe undoubtedly was nulliparous. There was no grossly visible evidence of a pathological condition in the reproductive tract.

Age Structure of the Population

Life tables were constructed (Deevey 1947) using the age distribution of female deer killed during the hunting seasons in McDonald

Forest during 1968 and 1969 (Tables 6 and 7). There were no significant differences in age distribution between years ($\chi^2 = 7.176$; $P > 0.50$, d. f. = 8), so that the age distribution of all females killed during both hunting seasons were combined into one life table (Table 8).

Table 6. Life table constructed using age distribution of female deer killed in McDonald State Forest in 1968.

Age Class	Number Killed	Number Killed per 1000	Number of Survivors per 1000	Survival Rate
I	31	260	1000	0.740
II	33	277	740	0.626
III	9	76	463	
IV	12	101	387	
V	11	92	286	
VI	9	76	194	0.701
VII	6	50	118	
VIII	4	34	68	
IX	4	34	34	

Table 7. Life table constructed using age distribution of female deer killed in McDonald State Forest in 1969.

Age Class	Number Killed	Number Killed per 1000	Number of Survivors per 1000	Survival Rate
I	23	270	1000	0.730
II	17	200	730	0.726
III	11	129	530	
IV	8	94	401	
V	14	165	307	
VI	6	71	142	0.657
VII	1	12	71	
VIII	2	24	59	
IX	3	35	35	

Table 8. Life table constructed using age distribution of female deer killed in McDonald State Forest in 1968 and 1969 combined.

Age Class	Number Killed	Number Killed per 1000	Number of Survivors per 1000	Survival Rate
I	54	265	1000	0.735
II	50	245	735	0.667
III	20	98	490	
IV	20	98	392	
V	25	122	294	
VI	15	74	172	0.683
VII	7	34	98	
VIII	6	30	64	
IX	7	34	34	

Several assumptions must be considered in using the time specific life table. These include: (a) the population is stationary, (b) all sex and age groups are equally vulnerable or information exists for making satisfactory adjustment of data, and (c) the cohort being added each year is of equal size (Quick 1963). The determination of whether a population is stationary is difficult (Caughley 1966). However, Caughley utilizes a series of age structures to evaluate whether a population of Thar (<u>Hemitragus jemlahicus</u>) is stationary. He utilized a 10 x 3 contingency table and concluded on the basis of probability using a χ^2 analysis that the populations were not different. The results can be interpreted as indicating a stationary population where the population is not increasing, or the three populations examined were increasing at the same rate and representing a stable population. The absence of a significant difference in the age structure of the female segment of the population in McDonald Forest during 1968 and 1969 is interpreted as representative of a stationary population. Support is provided by the "constant" natality rate between the two years, the similar success per hunter day, and the number of animals harvested. Males are not included in the analysis, so vulnerability of only the female segment need be considered. Hunters were unable to distinguish between yearling and adult does while hunting in McDonald State Forest. The percentage harvest of fawns in relation to the adults harvested was similar during both years. The fawn harvest was 56.5 percent of the total adult harvest in 1968 and 57.2 percent in 1969. There were no significant differences ($\chi^2 = 0.08$; $P > 0.80$; d.f. = 1) in harvest of fawns in proportion to adults between years. If a stationary population existed, the reproductive rate did not differ between years, and the proportion of fawns to adults in the harvest did not differ. It was assumed that the conditions for utilization of the time specific life table have been met. It was realized that a bias may exist relative to the willingness of the individual hunter to harvest a fawn. If the bias did exist, it appeared to be constant.

Time of Breeding Season

The initiation and peak of the breeding season was determined from the appearance of corpora lutea in ovaries collected during the fall. The does in McDonald Forest began breeding in the last half of October and reached a peak in the first half of November.

Differences in Physical Condition Between Years

The amount of fat surrounding the kidneys of each deer collected in McDonald Forest during gestation was limited. Only four of the 39 deer examined had indices of kidney fat of 30 percent or greater (Figure 1). Indices of condition based on kidney fat from deer collected in 1970, however, were significantly higher ($\chi^2 = 10.18$; $P < 0.025$; d.f. = 1) than the indices from deer collected in 1969 (Table 9).

Table 9. Numbers of deer collected in McDonald State Forest in each index category derived from kidney fat, with calculated expected frequencies in parentheses.

Year	Index of Condition			
	0.04-0.07	0.08-0.12	0.13-0.17	0.18+
1969	9 (5.35)	6 (4.87)	3 (5.35)	1 (3.41)
1970	2 (5.65)	4 (5.13)	8 (5.65)	6 (3.59)

The indices of condition based on bone marrow had a great variability. The "visual estimate" of the amount of fat, based on a scale from a low of zero to a high of six, ranged from zero to six (Table 10). Values of indices of condition based on the consistency of bone marrow ranged from 0 percent compression to 48 percent compression (Figure 2). No statistically significant differences were evident between years in distribution of indices of condition based on the visual rating of color and texture of bone marrow ($\chi^2 = 5.55$; $P > 0.30$; d.f. = 6) or in distribution of values of compression of bone marrow ($\chi^2 = 3.75$;

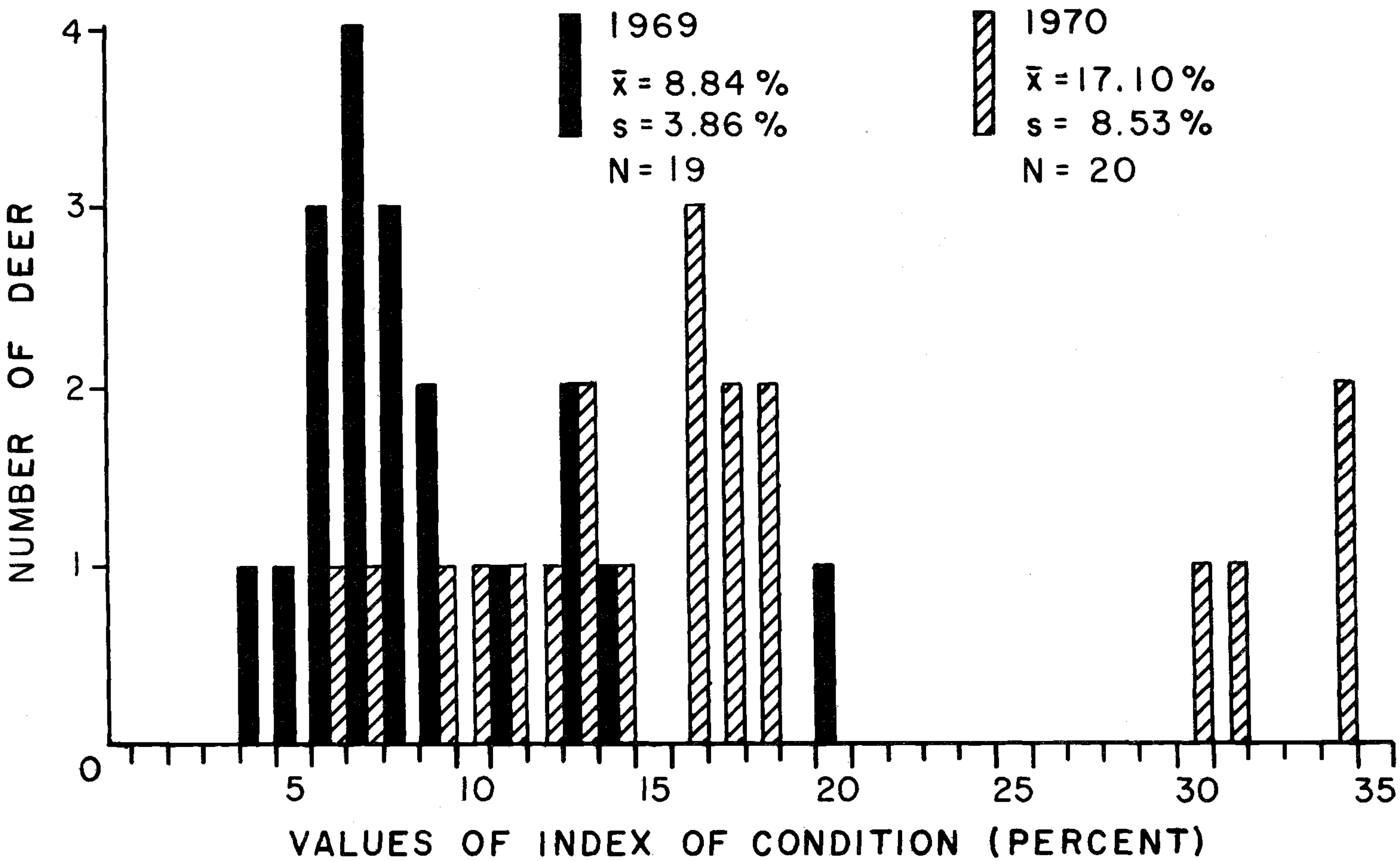

Figure 1. Frequency distribution of deer with various indices of physical condition based on kidney fat, March-May 1969 and 1970, McDonald State Forest, Benton County, Oregon.

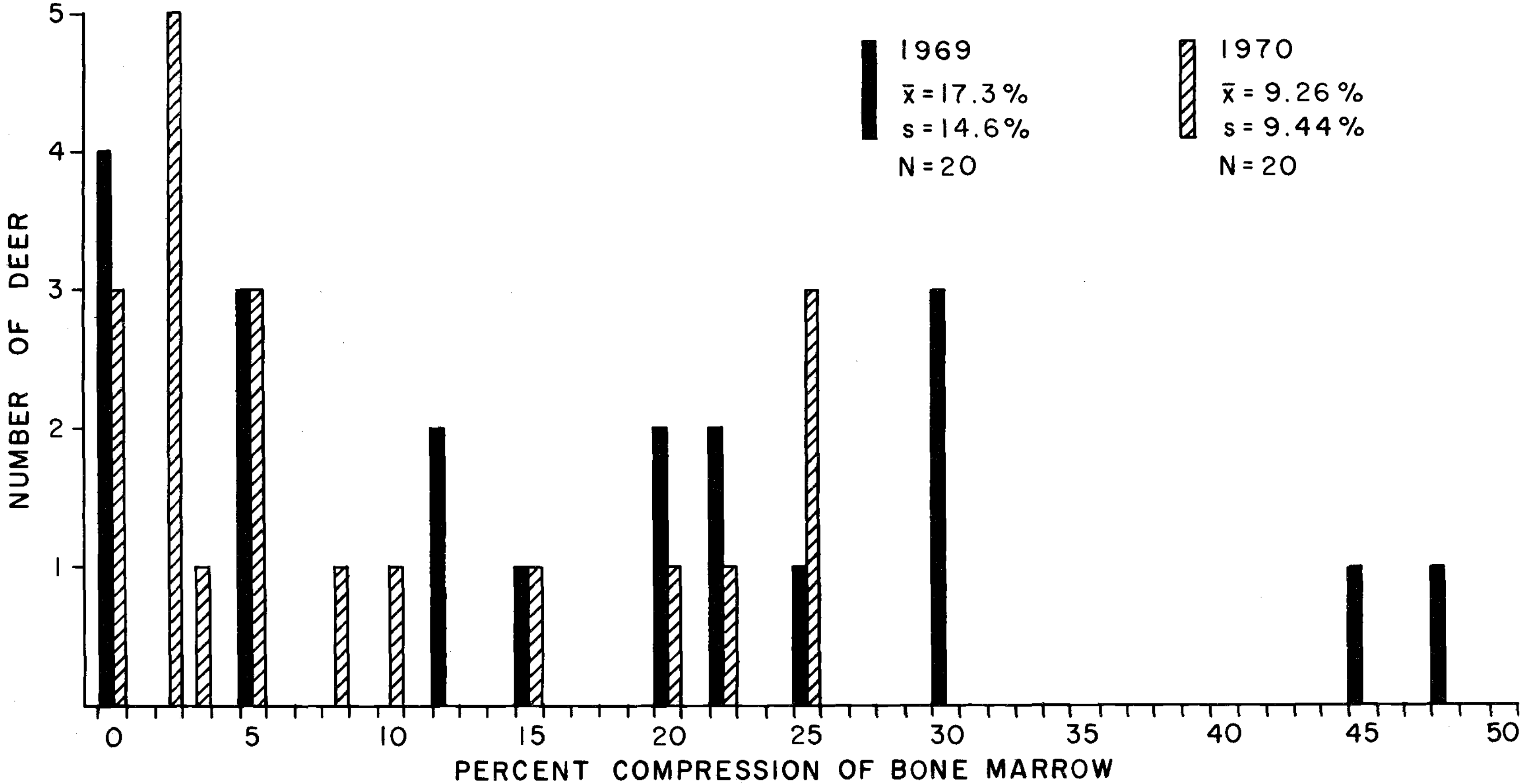

Figure 2. Frequency distribution of deer killed in McDonald State Forest, Benton County, Oregon, in 1969-1970 by percent compression of bone marrow.

P > 0.25; d.f. = 3) (Table 11). However, the mean percent compression in 1969 ($\bar{x}$ = 17.3) was higher than the mean for 1970 ($\bar{x}$ = 9.3).

Table 10. Frequency of deer assigned to each visual rating on the basis of the amount of fat in bone marrow from femur (low of zero to high of six) with calculated expected frequencies in parentheses.

	Rating						
Year	0	1	2	3	4	5	6
1969	4 (3.5)	1 (1.5)	3 (3.0)	5 (3.5)	2 (3.5)	5 (4.0)	0 (1.0)
1970	3 (3.5)	2 (1.5)	3 (3.0)	2 (3.5)	5 (3.5)	3 (4.0)	2 (1.0)

Table 11. Frequency of black-tailed deer assigned to each category on the basis of the percentage compression of bone marrow, March-May 1969 and 1970 with calculated expected frequencies in parentheses.

	Percent Compression			
Year	0 - 2	3 - 12	15 - 22	25+
1969	4 (6.0)	5 (5.5)	5 (4.5)	6 (4.5)
1970	8 (6.0)	6 (5.5)	3 (4.5)	3 (4.5)

Rate of fetal growth was used as an indicator of physical condition of the deer collected, because growth of the fetus depends on the level of maternal nutrition (Ommundsen and Cowan 1970).

Faster rate of growth of a fetus would result in an earlier estimated date of breeding because the date of breeding was estimated from the length of the fetus. Ninety-five percent of the breeding in 1968 was estimated by determining duration of embryonic development to have occurred between October 23 and December 2 (Figure 3), with

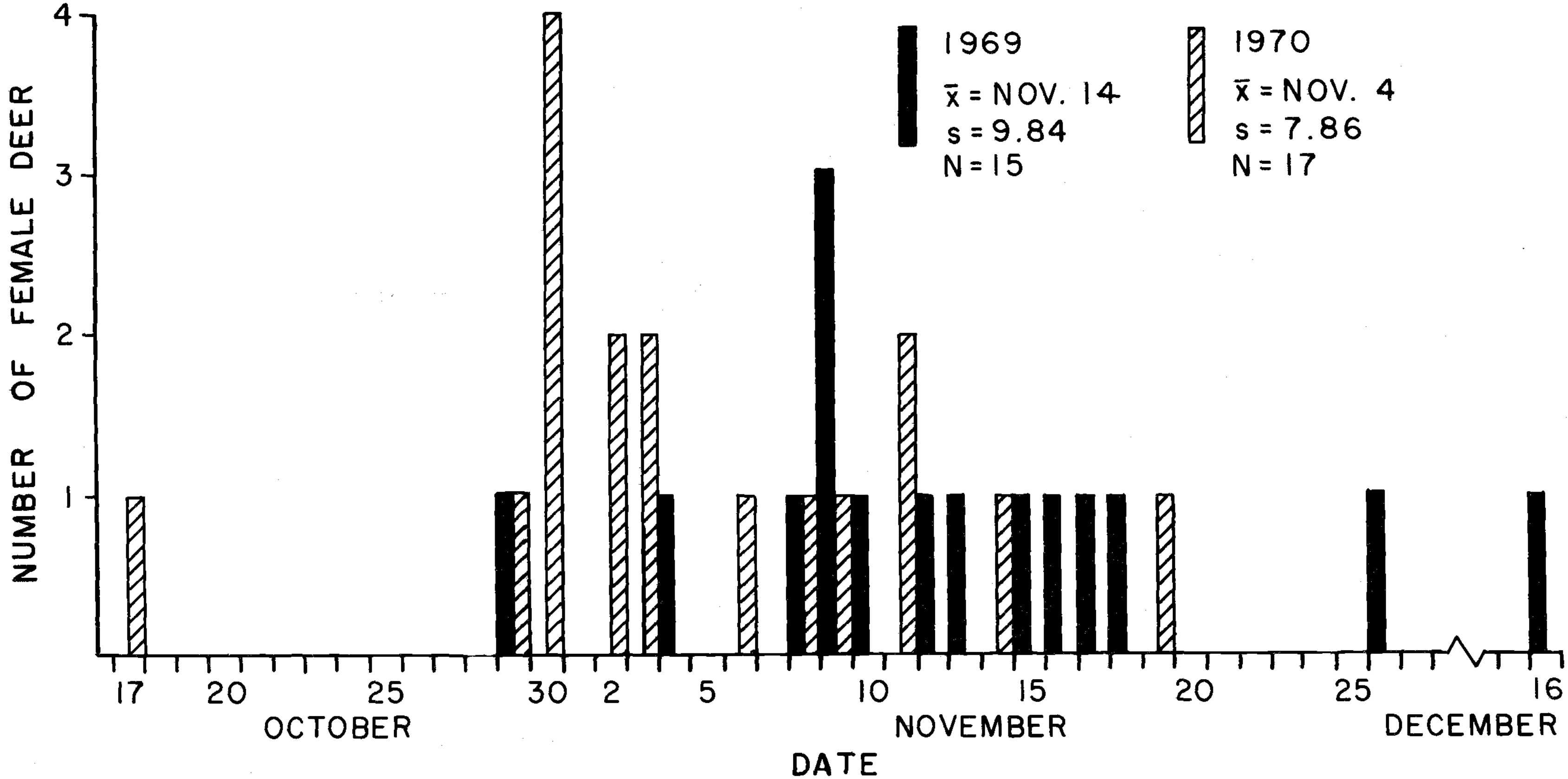

Figure 3. Frequency with which female black-tailed deer bred each date in 1969 and 1970 in McDonald State Forest, Benton County, Oregon. Dates calculated by determining the duration of embryonic development and counting backwards from the date which the deer was collected.

a mean date of November 14. In 1969, the mean date of conception was calculated as November 4, with 95 percent of the breeding estimated to have occurred between October 19 and November 20. The estimated dates of breeding in 1969 were significantly earlier (χ^2 = 9.42; P $<$ 0.025; d.f. = 1) than estimated dates of conception for fetuses from 1968 (Table 12). Because corpora lutea were evident in ovaries at the same time each fall (Table 13), actual dates of breeding were probably similar for 1968 and 1969. Thus, the earlier estimated dates of conception of fetuses from 1969 might have resulted from a faster rate of growth than that achieved by fetuses from 1968.

Table 12. Groupings of black-tailed deer according to estimated dates of breeding, 1969-1970, McDonald State Forest, Benton County, Oregon, with calculated expected frequencies in parentheses.

	Estimated Date of Breeding			
Year of Collection	October 17 - 31	November 1 - 8	November 9 - 14	November 15 +
1969	1 (3.3)	2 (3.75)	6 (4.7)	6 (3.3)
1970	6 (3.7)	6 (4.25)	4 (5.3)	1 (3.7)

Table 13. Percentage of yearling and adult black-tailed deer which had ovulated by time of collection from McDonald State Forest, Benton County, Oregon. (Sample size in parentheses.)

	Percentage Having Ovulated	
Date of Collection	1968	1969
Before October 26	14.3 (7)	14.3 (7)
October 26-November 7	28.6 (7)	66.7 (3)
November 8-10	94.1 (17)	87.5 (32)
November 16-17	93.3 (15)	---

Therefore, the statistically significant differences between years in the indices of condition based on kidney fat and on fetal growth rates gave positive support to the hypothesis that deer in 1970 were in better condition than deer collected in early 1969 following the harsh winter.

DISCUSSION

Corpora Lutea per Doe

Comparisons of rate of ovulation between age groups as expressed by corpora lutea per doe show significant differences between fawns, yearlings, and adults for each period of collection, with the exception of the yearlings in spring of 1970 (Table 2). The sample size of yearlings in spring 1970 was inadequate for comparison. Comparison within age groups between seasons and years of collection showed no significant differences with the exception of yearlings in spring, 1970, as noted above. Only 4 of the 7 yearlings collected in November, 1969, had ovulated. This reduced rate of ovulation probably was attributable to late ovulation by yearlings in the fall following a harsh winter. However, the small sample size precluded statistical evaluation. Absence of differences between periods of collection allowed the information for each age grouping to be pooled.

Comparison with Ovulation Rates of Other Areas

The rate of ovulation of adult deer collected in McDonald Forest was midway between the lowest (1.54) and highest (1.91) rates of ovulation found by Bischoff (1958) among five herds of black-tailed deer in California (Table 14). The average ovulation rates (1.75 for adults and 0.67 for yearlings) found by Taber (1953) among deer collected from a recently burned area in California, which he considered fair range, was almost identical with the rate of ovulation from deer collected in McDonald Forest. But deer collected from open brush land, which Taber (1953) considered good range, had a slightly higher rate of ovulation (1.89 for adults; 1.00 for yearlings) than deer collected from McDonald Forest. The average number of corpora lutea per doe found in adult deer killed in McDonald Forest was slightly higher than the rate of ovulation of adult deer (1.57) killed in comparable times of year in western Washington (Brown 1961), although yearlings from western Washington apparently had a higher incidence of corpora lutea per doe (1.15) than yearlings from McDonald Forest.

Table 14. Comparison of rates of ovulation among black-tailed deer herds in California, Washington, and McDonald State Forest, Oregon. (Sample sizes in parentheses.)

Authority	Corpora Lutea per Doe	
	Yearling	Adult
McDonald State Forest	0.79 (24)	1.76 (76)
Taber (1953)		
Recent Burn	0.67 (03)	1.75 (08)
Open Brush	1.00 (02)	1.89 (09)
Bischoff (1958)		
Tehama	---	1.91 (22)
Oak Knoll	---	1.54 (22)
Brown (1961)	1.15 (13)	1.57 (46)

Rates of ovulation from different areas are the result of varying levels of nutrition and population size. I interpret information in Table 13 to indicate that the level of nutrition for deer in McDonald State Forest supported above average reproduction rates at the time of the study.

Corpora Albicantia per Doe

Corpora albicantia can be used as an indicator of breeding success for the previous year (Golley 1957). Thus, corpora albicantia in the ovaries of a 2-1/2 year old deer indicate a probable pregnancy when the deer was a yearling. For this reason, data shown under the yearling age group in Table 4 were obtained from ovarian analysis of deer in age class III.

The number of corpora albicantia per doe was lower in ovaries collected during 1969-1970 than in ovaries collected during 1968-1969, indicating that breeding success during the harsh winter of 1968-1969 possibly was lower than the breeding success during the previous year.

Corpora albicantia per doe were lower than ovulation rates determined from corpora lutea per doe. For yearlings the rate of corpora albicantia per doe was only slightly below the average corpora lutea rate, but the number of corpora albicantia per adult doe was 17 percent lower than the average corpora lutea per adult doe.

For many reasons, corpora albicantia per doe were not used to estimate natality. Corpora albicantia per doe obtained from pregnant does in the spring were much lower than the rate found in the fall, indicating that corpora albicantia begin to disappear during the following pregnancy (Nalbandov 1964:171) and have completely disappeared macroscopically by the third cycle. Corpora albicantia can also result from sources other than degenerated corpora albicantia of pregnancy. Golley (1957), studying black-tailed deer in Washington, found rates of corpora albicantia per doe 18 percent higher than rates of corpora lutea per doe.

Sufficient information to evaluate the value of corpora albicantia as estimators of natality was not obtained. More data need be collected and evaluated to understand more fully the significance of rates of corpora albicantia.

Fetuses per Doe

Although 22 fetuses were obtained from 20 deer collected during the spring of 1969, and 30 fetuses were removed from 20 deer collected during the spring of 1970, there was no statistical difference between years in numbers of fetuses per adult doe. The number of fetuses per yearling doe was much higher in 1970, but the sample of yearlings in 1970 was too small for comparison with the previous year. There appeared to be greater production in 1970 than after the severe winter in 1968-1969, yet small sample size precluded statistical support of the difference in production. Because productivity of deer differs with physical condition (Longhurst et al. 1952) and the level of nutrition (Longhurst 1950, Morton and Cheatum 1946, O'Roke and Hamerstrom 1948, Severinghaus 1951. Verme 1965) -- which in turn affects the physical condition of the deer -- a lower natality was expected after the more severe winter of 1968-1969. Because there were no statistically significant differences in natality between years, data were combined for purposes of estimating natality.

Estimates of Natality

The number of fetuses per doe provides the best estimator of natality, because it is obtained closest to the time of birth, and because actual fetuses are being counted rather than ovarian structures. However, it usually is not practical to collect a representative sample from the population every spring. An estimate based on data collected from animals taken during the fall hunting season would be more practical. Hunters are responsive to requests for providing reproductive tracts for examination and large numbers of reproductive tracts are generally available during permit seasons.

There was no statistically significant difference between rates of ovulation in the fall and rates of fetuses obtained in the spring during the two years of this study. Over all periods of collection, the rate of corpora lutea per doe collected during November differed from the fetal rate by only 0.04. Multiplication of the corpora lutea per doe by 0.96 (1.00-0.04) should adjust corpora lutea per doe to compensate for the slight difference between the observed rate of ovulation and the fetal rate and provide a realistic estimate of natality. If the adjustment factor of 0.96 was stable from year to year over an extended period, the rate of ovulation as determined from examination of ovaries obtained in November would provide an adequate estimator of natality. Additional years of investigation would be needed to determine annual variability in the number of fetuses per doe during the spring in order to determine the reliability of the adjustment factor and the necessity of using the adjustment factor in making predictions of parturition rates.

Estimates of Population Maintenance

One of the goals in managing an exploited species is to maintain a population of animals that can yield a stable harvest over a sustained period of time (Leopold 1933). The number of animals harvested should be determined by the number that can be removed without damaging the ability of the population to maintain itself at the level desired to accomplish the objectives of management. This is especially true for a heavily hunted area, such as McDonald Forest. Population maintenance can be estimated from the survival rate of the population, provided by a life table, combined with the reproductive rate of the population (Henny et al. 1970).

The proportion of female yearlings in the sample from which reproductive rates were determined was lower than the proportion of female yearlings in the population as determined from deer killed by hunters. Therefore, reproductive rates were adjusted to correspond to the age distribution shown in the life table constructed from the combined harvest of 1968 and 1969. This adjustment was accomplished by multiplying the reproductive rate of yearlings by 50 (the number of yearlings in the life table), multiplying the reproductive rate of adults by 100 (the number of adults in the life table), adding these two products, and dividing the sum by 150 (total number of yearlings and adults in the life table). These adjusted reproductive rates were termed "weighted fetal rate" and "weighted rate of ovulation".

The relationship between the number of female fawns produced per female of reproductive age, survivorship, and a stable population can be expressed in the formula

$$\overline{m} = \frac{1 - s}{s_o \, s_1}$$

where $\overline{m}$ = ratio of number of females produced to number of females of reproductive age,

s_o = survival rate of fawns from birth to the beginning of the hunting season in their first year,

s_1 = survival rate of deer between the beginning of the hunting season during their first year to the beginning of the hunting season the following year,

s = average survival rate of deer each year after the beginning of the hunting season during their second year of life.

Since utilization of this formula concerns only females, $\overline{m}$ is equal to one-half of the reproductive rate, assuming an equal sex ratio at birth. Survival rates are obtained from the life table.

The value for s_o in the life table, however, may have been over-estimated, due to hunter bias against shooting fawns. But solving the above equation for s_o will yield the survival rate for females of age class I consistent with a stable population. If the actual s_o does not have a value consistently lower than the calculated s_o, the population will maintain itself.

The weighted rate of fetuses per doe for the population in 1969 and 1970 was 1.36. Using a value of $\overline{m}$ equal to one-half the weighted fetal rate, the calculated s_o consistent with a stable population was 0.698. Thus, females in age class I in this deer population in McDonald Forest could sustain a mortality rate of 30 percent between birth and the beginning of the first hunting season and still maintain the population.

If the fetal rate were not available, s_0 may be calculated from the ovulation rate determined from deer collected during the November hunting season. The weighted rate of ovulation for all does of reproductive age collected during November of 1968 and 1969 was 1.42 corpora lutea per doe. This rate multiplied by the adjustment factor -- determined as 0.96 during this period of collection -- gives a product of 1.36, the same value as the weighted fetal rate used to obtain $\overline{m}$ above.

The acceptable mortality rate for age class I calculated from fetuses per doe, or adjusted ovulation rate, was higher than the mortality rate for age class I in the hunting kill. Therefore, I conclude that this population of black-tailed deer in McDonald Forest had the potential to maintain itself while being harvested under the liberal hunting regulations employed during the study without relying on ingress from surrounding areas.

State of the Population

The classical S-shaped, or sigmoid, population growth curve, representing the growth of a population toward its ultimate size limit, may be expressed as an increment curve showing the amount of gain per unit time (Scott 1954). Such a curve shows that gains are at a maximum on only one point in the stages of growth of a population.

This is the point of optimum yield, where production is at its highest.

This point of optimum yield corresponds with the inflection point on the sigmoid growth curve (Scott 1954). Often a higher yield can be obtained by modifying the size of the basic population to bring the population numbers to the inflection point on the sigmoid curve.

The age structure within a population may be correlated with its position on the sigmoid curve (Scott 1954). A population with an age distribution of predominantly young animals characterizes the accelerating phase of population growth, whereas an age distribution with more older animals characterizes a population which has stopped growing.

The older age classes were well represented among the deer population in McDonald Forest. Almost 30 percent of the deer were in age class V or higher. Only 51 percent of the deer in this population sample were in age classes I and II. Thus, this deer herd is probably slightly above the point of optimum yield.

Many deer in McDonald Forest appeared to be in poor physical condition during both winters, although their overall condition was worse during the severe winter. Ransom (1965) stated that when the index of condition based on kidney fat had a value below 30 percent, deer began to mobilize fat reserves in bone marrow. This fat in bone marrow is the last fat depot to be mobilized (Riney 1955), so the deer in McDonald Forest were utilizing their last available fat depot, even during the relatively mild winter of 1969-1970.

A further reduction in the basic size of the population -- accomplished by increasing the level of the harvest -- might achieve two favorable results: the remaining deer might be able to sustain themselves in better physical condition, and the population could be stabilized at the inflection point on the growth curve where production is highest. If a further reduction in the population is compensated for by a higher reproductive rate for the population, the decrease in numerical size of the basic population will result in the population more closely approximating the point of optimum yield.

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