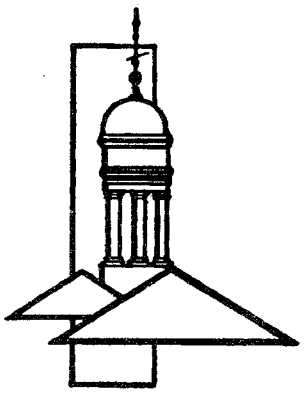

WISCONSIN STATE UNIVERSITY

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THE MUSEUM OF NATURAL HISTORY

Reports on the Fauna and Flora of Wisconsin

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ABSTRACT

Reproduction was studied in female white-tailed deer (*Odocoileus virginianus*) collected from three central Wisconsin management areas during the 1968-69 gestation season.

Cotyledon size increased rapidly during the first stages of gestation with maximum development at about 100 days of pregnancy. The number of cotyledons in 44 female deer varied from five to nine, with six being most common. Nine deer had more than six cotyledons and two had fewer than six.

In does that ovulated an ovum from each ovary and produced twin fetuses, no interhorn migration occurred and each horn contained a fetus; when two ova were released from a single ovary, one developed in the horn adjacent to the ovulating ovary and the other migrated to the opposite side. In six animals with a single ovulation in either the left or right ovary, movement of the ovum to a horn opposite the ovulating ovary occurred 50 percent of the time. In the instance of migration where a number of cotyledons in each horn differed from the usual number of three, the fetus was in the horn with a higher number of cotyledons.

The primary sex ratio of 155 males to 100 females was considerably higher than that reported for 11 other states, the ratio of male to female fetuses was significantly higher for single fetuses than for twins. Prenatal loss as dead embryos was greatest in fawns (80 percent); in adults and yearlings losses through mid-pregnancy were 7.5 percent. Where twin fetuses were involved in prenatal deaths, both had died.

Gravid fawns showed an average of 2.00 $\pm$ 0.00 corpora lutea and 1.67 $\pm$ 1.47 fetuses per doe; yearlings contained 1.33 $\pm$ 0.37 corpora lutea and 1.22 $\pm$ 0.34 fetuses; adults produced 1.91 $\pm$ 0.13 fetuses from 2.04 $\pm$ 0.17 ovulations each. The difference between the number of ovulations and the number of fetuses was greatest in fawns and least in adults. Previous breeding was detected in 14 of 22 adult deer; they produced an average of 1.57 $\pm$ 0.88 corpora albicantia each.

Most of the yearlings and adults were bred between November 1 and November 28, with a peak during the week of November 8-14; a single fawn was bred 4-5 weeks later. Eighty percent of the fawn births would have occurred during the 3-week period May 20 to June 9.

INTRODUCTION

The white-tailed deer (*Odocoileus virginianus*), the most important big game species in North America, has been extensively managed. The major goal of modern management is to regulate deer numbers within the carrying capacity of their range by legal annual harvests. Many studies have attempted to define carrying capacity of various types of range and to measure the effects of range quality on the reproductive performance of different age groups of deer. An immediate goal of many studies on reproduction is to estimate annual recruitment in the population. Some of the finer details regarding prenatal life of deer have been ignored.

Little is known about the interuterine horn migration of ova or the apportionment of uterine cotyledons among fetuses in white-tailed deer. The major objectives of this study are: (1) to determine the extent of interuterine horn migration of ova; (2) to study the apportionment of uterine cotyledons among fetuses in white-tailed deer; and (3) to measure deer productivity and determine the time of occurrence of fawn pregnancies in central Wisconsin.

ACKNOWLEDGMENTS

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METHODS AND MATERIALS

Reproduction was studied in female deer from three central Wisconsin management areas (Units No. 53, 56, 57) during the 1968-69

gestation season. Most specimens were vehicle-killed, but two female yearlings dying of other causes were collected on the Sandhill Wildlife Demonstration Area in February and March.

Gravid uteri and associated reproductive structures were collected by Wisconsin Department of Natural Resources personnel between December 28, 1968, and May 20, 1969. The tracts were frozen in plastic bags and stored at the Sandhill Wildlife Demonstration Area until they were delivered to the University. Deer that furnished material were aged as fawns, yearlings, and adults by Natural Resources personnel on the basis of tooth replacement and wear.

After the materials were thawed the ovaries were excised, labeled right or left as appropriate, and stored in 10 percent formalin. In reproductive tracts the location and attachment of fetuses were noted before they were removed. Fetal lengths (crown--rump or forehead--rump) were recorded. These measurements were taken as the fetus was lying on its side, the back alongside a meter stick.

Fetuses were aged with the aid of a growth curve constructed from data published by Cheatum and Morton (1946) for white-tailed deer in New York. After establishing dates of breeding, a gestation period of 200 days was used to calculate dates of fawning (Severinghaus and Cheatum, 1956: 95-99).

Each ovary was examined externally for evidence of ovulation, sectioned in the plane of its longest dimension into 1-mm slices, and examined macroscopically for corpora lutea of pregnancy and corpora albicantia of the corpora lutea of pregnancy. Unusual variations in size or structure were recorded.

RESULTS AND DISCUSSION

Placentation and Implantation

The uterus of the white-tailed deer is bicornuate; the vaginal one third is fused externally but separated internally be a septum. Each horn coils ventrally and laterally from the uterine body one to one and one-half turns, then turns outward to join a convoluted oviduct (Sinha et al. 1969: 202). Placentation is cotyledonary, with limited growth of placental tissue and incomplete fusion of fetal and maternal parts. Tufts of chorionic villi invade the cotyledons and form functional units (placentomes) through which nutritive and gaseous exchange takes place--common usage has established the term cotyledon for this composite structure (Cole and Cupps, 1969: 397-400).

Maternal cotyledons exist as local thickenings of non-glandular connective tissue projecting into the lumen of the uterus. With the onset of pregnancy and ensuing placentation they enlarge and become functional maternal elements. The number of cotyledons in ruminants varies from about 180 in the goat to five or six in roe deer; sheep and cattle have numbers between those extremes (Parkes, 1952).

Embryonic development begins with the stimulus of fertilization. After a period of initial cleavage lasting 3-4 days developing zygotes arrive in the uterus (Cole and Cupps, 1969: 387). In white-tailed deer the time of implantation is difficult to determine; however, breeding experiments indicate that embryos begin implanting 28-31 days after fertilization takes place (Severinghaus and Cheatum, 1956: 60).

Table 1. Number of cotyledons per uterine horn in a sample of 44 female deer of all ages from central Wisconsin.

Cotyledon distribution		Number of occurrences
Right horn	Left horn	
3	3	33*
3	4	2
3	2	1
3	5	2
5	4	1
4	4	3
4	3	1
2	3	1
	Total	44

*Includes all of 13 female fawns examined in the study.

Morphology and Occurrence of Cotyledons

The number of cotyledons in 44 adult, yearling, and fawn does from central Wisconsin varied from five to nine, with six being most common (Table 1). All of the 13 female fawns and 20 of the 31 older deer had three cotyledons in each horn. Of the 11 remaining deer (yearlings and adults), nine had more than six cotyledons, and two had fewer than six. The mean number of cotyledons was practically the same in yearlings (6.43) as in adults (6.45).

Cotyledon size increased rapidly during the first stages of gestation with maximum development at about 100 days of pregnancy. The average dimensions of 12 cotyledons between 105 and 114 days of pregnancy were 71.6 mm in length and 37.2 mm in diameter. Variation in size occurred most often when the number of cotyledons in a horn differed from three; most accessory cotyledons were small. Unusually large cotyledons were common in horns containing fewer than three.

Intrauterine Distribution of Fetuses

The distribution of fetuses in the uterine horns in deer has not been documented, but it has been well studied in other ruminants (Parkes, 1952; Nalbandov, 1964; Cole and Cupps, 1969).

The distribution of embryos within the uterus is modifed by some interuterine horn migration. Two eggs released from a single ovary distribute one in each horn; a single egg generally remains in the horn adjacent to the ovulating ovary; movement into the other horn has been reported in sheep (3-50 percent); goats, horses, and rarely primates (Cole and Cupps, 1969: 388; Nalbandov, 1964: 233). In sows, interuterine horn migration of ova resulted in nearly equal distribution of surviving fetuses in the two horns (Nalbandov, 1964: 233).

Frequency of ovulation from the two ovaries and distribution of fetuses in the uteri of 35 adult and yearling female deer are given in Table 2.

Table 2. Frequency of ovulation from the two ovaries in white-tailed deer and distribution of fetuses in the two uterine horns.

Age class of deer	Number of corpora lutea				Number of fetuses			
	Right ovary		Left ovary		Right horn		Left horn	
Yearling	7	(58.3)*	5	(41.7)	4	(36.4)	7	(63.6)
Adult	21	(41.0)	30	(59.0)	23	(51.0)	22	(49.0)
Combined	28	(44.4)	35	(55.6)	27	(48.2)	29	(51.8)

*Percent values shown in parentheses.

The 45 fetuses from adults were distributed almost equally in the two horns of the uterus. The difference between ovulations from the left ovary (59 percent) and the number of fetuses found in the left horn (49 percent) shows some movement of ova to the right horn.

Of the 11 fetuses from yearlings, seven (63.6 percent) were in the left horn and four (36.4 percent) were in the right, indicating that migration of ova occurred to the left side. However, the apparent deviation from an equal distribution of fetuses probably may reflect too small a sample size.

In single pregnancies the chorion extended into the contralateral horn and the fetus implanted on cotyledons in both horns; but in animals having twins, the chorions were fused or remained independent near the cervix, and each fetus implanted on the cotyledons in the horn where it occurred. This agrees with the findings of Sinha et al. (1969: 202) for white-tailed deer in Minnesota.

The fetuses in all of 22 twin pregnancies and in six of seven single pregnancies (50 fetuses) implanted on all cotyledons available. In another pregnancy with a single fetus in the right horn, one of three cotyledons in the left horn was not utilized.

The influence of cotyledon number on the migration of zygotes to a contralateral horn of the uterus were studied in six cases involving single ovulations (Table 3).

Table 3. Intrauterine migration in instances of single ovulations and relationship of number of cotyledons to distribution of fetuses.

		Distribution of fetuses		Cotyledon number		
Ovulations	Specimen number	Left horn	Right horn	Left horn	Right horn	Uterine Migration
Single ovulation left	36	1	-	3	3	no
	46	-	1	3	5	yes
	53	1	-	3	2	no
Single ovulation right	40	1	-	3	3	yes
	47	-	1	2	3	no
	52	1	-	3	3	yes

Interuterine horn migration occurred in three of the six pregnancies (50 percent); movement always was to a horn having an equal or higher number of cotyledons. A larger sample may show migration to a horn having fewer than three cotyledons. Therefore, an effect of

cotyledon number on the migration of zygotes to a contralateral horn was not determined.

The distribution of fetuses within the horns of the uterus may simply be a function of chance operating before the time of implantation. Later intrauterine migration of embryos does not occur. An unattached zygote might by chance move to the contralateral horn; but after implantation, embryonic growth and the development of extraembryonic membranes would prevent further movement of this type.

Primary Sex Ratios

Of the 51 embryos from 34 adult and yearling does from central Wisconsin, 31 (56 percent) were males, a primary sex ratio of 155 males to 100 females (Table 4.)

Table 4. Primary sex ratio of 51 embryos from 34 adult and yearling female white-tailed deer collected in central Wisconsin during the 1968-69 gestation period.

	Embryos				
Does with	Male	Female	Total	Percent males	Males per 100 females
Singles	5	2	7	71	250
Twins	26	18	44	59	149
All litters	31	20	51	56	155

A Chi-square test showed that the probability of a deviation of this magnitude from a 1:1 ratio occurring by chance is about 20 percent ($X^2 = 2.36$ with one degree of freedom). The ratio of male to female fetuses was higher for single fetuses than for twins; five of seven single fetuses (71 percent) were males and 26 of 44 twin fetuses

(59 percent) were males. The sex ratio of combined litters is almost identical with the primary sex ratio of 151 males to 100 females (60 percent) that Dahlberg and Guettinger (1956: 87) reported for a sample of 168 white-tailed deer embryos from Wisconsin. This ratio for Wisconsin deer is considerably higher than that of 117.2 males to 100 females reported for white-tailed deer from 11 states by Severinghaus and Cheatum (1956: 66); however, such unexplained differences in primary sex ratios between states are not uncommon (Dahlberg and Guettinger, 1956: 87).

Prenatal Mortality

Prenatal losses as dead embryos occurred in all age groups, but was greatest in the fawn group. Where twin fetuses were involved, both had died. The two pregnant fawns with twins carried atrophic fetuses--a loss of 80 percent of the five fetuses produced by fawns. Deterioration prevented exact aging, but a comparison of the fetuses to descriptions of developmental stages in mule deer by Hudson and Browman (1959: 301) indicated that death had occurred after the 14th week.

Three of 32 adult and yearling does carried four atrophic fetuses representing 7.5 percent of the 53 fetuses from these age groups. One yearling doe contained two dead fetuses, and two adult does had one each. Two fetuses were partially decomposed, but the ages of the other two were estimated at 93 days and 110 days of age at death (about 14 weeks). The mortality rate of 7.5 percent at mid-pregnancy was found in yearling and adult does by Roseberry and Klimstra (1970: 27), who projected that rate to estimate a total prenatal mortality of 10-12 percent for white-tailed deer in southern Illinois.

More energy is required to carry twins through the gestation period than to support a single fetus. As food decreases through winter, energy becomes increasingly more difficult to obtain. The atrophic fetuses collected from fawn and yearling does late in the gestation period probably represent deaths from insufficient energy available to support both doe and fawns (Severinghaus and Cheatum, 1956: 103).

Productivity

Of the 47 tracts available for analysis, 15 were from fawns (deer between 7 and 12 months of age), 10 were from yearlings (deer between 19 and 24 months of age), and 22 were from adults (animals older than 24 months). Pregnancy records are shown in Table 5.

Table 5. Pregnancy records for 47 white-tailed does collected in central Wisconsin during the 1968-69 gestation period.

Age class	Number of deer	Number Pregnant	Fetuses		Ovulation		Loss of ova (%)
			No.	Rate	C.l.	Rate	
Fawn	15	3 (20)*	5	1.67±1.47	8	2.00±0.00	37.5
Yearling	10	9 (90)	11	1.22±0.34	12	1.33±0.37	8.3
Adult	22	22 (100)	42	1.91±0.13	45	2.04±0.17	6.7
Totals	47	34 (72)	58	1.70±0.25	65	1.91±0.14	10.8

*Number in parentheses is a percentage.

Dahlberg and Guettinger (1956: 84) reported that fawn pregnancies were rare in Wisconsin. A recent study of reproductive tracts collected in central Wisconsin during the 1963 fall hunting season revealed that

ovulation had occurred in one of 10 fawns and the ovaries of six others contained large follicles that possibly could have developed to maturity (Moore and White, unpublished). In the present study, ovulation occurred in four of the 15 fawns; however, only three (20 percent) were pregnant--two carried twins and one contained a single fetus, as mentioned above. The three gravid fawns showed an average of 1.67 ± 1.47 embryos; the 95 percent confidence interval includes the fetal rates of older deer, but there is a statistical difference between the reproductive rates of adults (1.91 ± 0.13) and yearlings (1.22 ± 0.34). The difference between ovulations determined from corpora lutea (eight) and the number of fetuses present (five) represents a 37.5 percent loss of ova. This is somewhat higher than the 21.4 percent loss of ova reported by Roseberry and Klimstra (1970: 25) for white-tailed deer fawns in southern Illinois. Robinette et al. (1955: 122) indicated a high percentage loss of ova in Utah mule deer fawns 6-8 months of age. Both Wisconsin and Utah represent more rigorous environments than southern Illinois.

In the 20 adult and yearling does with twins, the number of fetuses did not exceed the corpora lutea. Hence, there was no evidence of monozygotic (identical) twinning.

The yearlings as a group were less productive than the older does. Nine of the 10 yearlings had experienced estrus at the time of their deaths, producing an average of 1.33 ± 0.37 corpora lutea each. Three deer contained two corpora lutea and the remaining six had one each. The 11 fetuses resulting from 12 ovulations, showed an 8.3 percent loss of ova. The ovulation rate determined from corpora lutea (1.33 ± 0.37) and the fetal rate based on visible embryos (1.22 ± 0.34) are lower than those rates found in white-tailed deer from New

York's best range (Severinghaus and Cheatum, 1956: 101), and in Iowa (Haugen and Trauger, 1962: 235), where most yearling deer produce twins.

All adult does had experienced estrus and produced an average of 2.04 $\pm$ 0.17 corpora lutea each--high productivity for a sample including all adult age groups. Two of the deer contained three corpora lutea, 19 of them produced two ova each, and the remaining doe produced a single ovum. The adults showed a lower rate of ovum loss (6.7 percent) than did younger does. The incidence of pregnancy in this group was 100 percent; therefore, the group fetal rate (1.91 $\pm$ 0.13) and the rate per pregnant animal are the same.

Of the 22 adult deer, 14 (64 percent) contained pigmented corpora albicantia in their ovaries, indicating previous pregnancies. These animals produced a total of 22 corpora albicantia, or 1.57 $\pm$ 0.88 each. Those deer without corpora albicantia may be 2-year-olds which were not pregnant as yearlings, or they could be older deer which failed to breed the previous year. Otherwise, the corpora albicantia may have become obscured and were overlooked in the analysis.

The small sample size and the possibility of error in detecting corpora albicantia nullifies any conclusion that the ovulation rate determined from corpora lutea (2.04 $\pm$ 0.17) and the rate derived from corpora albicantia (1.57 $\pm$ 0.88) represent greater productivity in 1969 than in 1968.

Breeding and Fawning Seasons

Breeding dates by weekly interval are given for 30 adult and yearling does (Figure 1). Not included is a single female fawn that was bred during the week of January 2-9. Breeding activity was greatest

during a 4-week period from November 1 to November 28 when 94 percent (28 of 30) of the does conceived; breeding reached a peak in the week of November 8-14. The earliest breeding occurred during the week of October 25-31 and the latest between November 29 and December 5. In a sample of 32 does from central and northern Wisconsin, Dahlberg and Guettinger (1956: 43) found that 62 percent of all breeding does conceived during November 10-29; they found a tendency for earlier breeding in central Wisconsin. The peak of breeding in yearlings is similar to that of the adults. Although a breeding peak for fawns could not be determined, the 4-week interval between the last breeding of an adult in early December and the breeding of the female fawn is about the same delay in fawn breeding reported by Cheatum and Morton (1946: 256) for New York, and by Roseberry and Klimstra (1970: 27) for Illinois.

With a breeding peak of November 8-14 and a gestation period of 200 days, the calculated peak of fawning would be May 27 to June 2, with 33 percent of all adult and yearling does producing young during this time. Most does would give birth during the 3-week period May 20 to June 9, when 80 percent of the fawn births would occur.

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