Reproductive Ecology of White-tailed Deer on the Welder Wildlife Foundation, Texas

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Abstract: Long-term reproductive, physiological, and population data are not commonly available for deer herds. In Texas, there is little data on populations that are not commercially hunted. Data were recorded from 943 white-tailed does (*Odocoileus virginianus*) collected from 1961–1992 on the Welder Wildlife Foundation. Age class, eviscerated carcass weight, kidney fat index, density, and rainfall were correlated with reproductive performance including birth dates, pregnancy rates, and counts of corpora lutea and embryos. Deer densities averaged 33/km^2. Mean conception date was 22 November and 75% of the breeding occurred in November. Pregnancy rates for fawns, yearlings, and adult does were 5%, 90%, and 95%, respectively. Yearlings averaged 1.39 corpora lutea and 1.28 embryos. Adults averaged 1.83 corpora lutea and 1.68 embryos. Fetal sex ratio was 52% males. At relatively high densities deer continued to produce at a high rate and number of corpora lutea and embryos were density-dependent. Below average rainfall did not significantly affect pregnancy rates; However, number of embryos was reduced. Age, eviscerated carcass weight, and kidney fat index were positively correlated to number of embryos. Density was negatively correlated to eviscerated carcass weight, kidney fat index, and number of embryos.

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Collection of reproductive data from white-tailed deer on the Welder Wildlife Foundation (WWF) began in 1961 and are compiled through 1992. This data set provided an opportunity to correlate age class, body weight, kidney fat index (KFI), reproduction, density, and rainfall.

Long-term data sets present some analysis difficulties because different people assist with data collection resulting in inherent variability. Additionally, other variables such as habitat modification and weather patterns cannot be completely accounted for in the data analysis and therefore statistical analysis is difficult. However, long-term data sets with large sample sizes provide more accurate averages and descriptive characteristics.

Age, density, and habitat characteristics all influence reproduction with regional variability in reproductive timing and potential (Teer et al. 1965, Harwell and Barron 1975, Haugen 1975, and Rhodes et al. 1985). Nutrition also affects the reproductive potential of deer (Verme 1969, Ozoga and Verme 1982). Long-term reproductive, physiological, and population data are not commonly available for deer herds. Also, data are often collected during hunting seasons when reproductive data are incomplete because of no or minimal fetal development. In Texas there is little data from populations that are not actively managed (i.e., sex ratios, population density, harvest quotas) or not commercially hunted. The objectives of this paper are to describe the phenology of reproduction and the effects of age, condition, density, and rainfall on reproduction using a long-term data base.

Methods

The 3,157-ha WWF, a working cattle ranch, is located 37 km north of Corpus Christi in the Coastal Bend region of Texas. The WWF lies in a transitional zone between the Gulf prairies and marshes and the South Texas plains (Hatch et al. 1990). Plant communities and associated soils were described by Drawe et al. (1978). Rainfall averaged 89.8 cm/year (WWF records). Stocking rates have ranged from 1 AU/2.8 ha to 1 AU/8.1 ha and have averaged 1 AU/6.1 ha. An AU represents a mature cow with calf.

The WWF deer herd is not managed according to a management plan or specific management goals nor is it commercially hunted. Rather, the WWF has chosen not to control numbers by hunting, predator control, or vegetation management beyond what is done with grazing regimes and brush management. Deer on the WWF have been collected for graduate student research projects and WWF staff have collected deer for information on reproduction and condition. Many graduate students and different WWF staff have participated in collecting and recording this data. From 1961 to 1992, 1,901 deer were collected (1,280 females, 621 males). Reproductive data were recorded for 943 deer collected primarily from January through April during the time period.

Data recorded in the various studies included age; weights; counts of corpora lutea; embryo sex, numbers, weights, crown-rump length, and tarsal length; and KFI. Reproductive data provided information on breeding season, birth dates, pregnancy rates, and fetal sex ratios. Number of corpora lutea and embryos/yearling and adult were determined using pregnant females. Pregnancy rates were determined by the presence of embryos. Females not carrying an embryo by 1 January were considered not pregnant. Fertilization rates were calculated by comparing number of corpora lutea to embryos. Eviscerated carcass weights (ECW) were used to compare weights without embryos. Date of conception was calculated for each measurable fetus using crown-rump length (Hamilton et al. 1985). A gestation period of 200 days was used to determine birth date. Deer were aged using tooth wear and replacement (Severinghaus 1949) and compared to known-aged jaws from the WWF. The KFI was determined following Riney (1955).

Age classes during the studies were defined as follows: fawns, 0–12 months; yearlings, 13–24 months; 2 years old, 25–36 months; 3 years old, 37–48 months; 4 years old, 49–60 months; 5 years old, 61–72 months; and 6 years old, ≥73 months. Deer were considered adults when ≥2 years old.

Deer population estimates have been conducted on WWF since 1963. Until 1974, estimates were determined by line transects and expanded to the entire refuge. Beginning in 1975, at least 1 aerial census has been conducted annually by helicopter. Flight lines were established on the refuge grid that had permanent markers on each 16.2-ha block. A 50%-coverage census has been conducted using the established flight lines and a 200-m transect width. No correction factors were used to increase density estimates; therefore, number reported is an index of minimum population size.

Pearson correlation coefficients were calculated for corpora lutea, embryos, conception date, KFI, density, and age. ECW and KFI were used as indicators of condition. Paired t-tests were used to determine the significance between the number of embryos and ECW and KFI. Does with higher weights and KFI indexes would be considered in better condition and therefore would have a higher reproductive potential. Does were divided into the 7 age classes and divided again into 2 weight categories. The fawn age class was excluded from analysis because of the small sample size. Median weight for each age class was determined and those below the median were placed in the low weight category. Those above the median were placed in the high weight category. Does were divided into 2 KFI categories based on the median and according to age class. Also, the KFI data were analyzed by using the median to divide data into high and low categories regardless of age class. A paired t-test was used to compare pregnancy rates and number of embryos to years of above or below average rainfall. Statistical significance was accepted at $P \leq 0.05$. This is WWF Contribution No. 436.

Results

Early methods of ground counts and fixed-wing aircraft used to estimate white-tailed deer density were more variable than estimates from helicopter surveys. Annual density estimates show a general downward trend over time (Fig. 1). A regression analysis of density indicates a negative slope (−0.66) with an r^2 value of 0.56 ($P = 0.0001$). A range of 60 deer/km^2 (1970) to 16.3 deer/km^2 (1989) was recorded (Fig. 1). The population almost doubled in 4 years from 16.3 deer/km^2 in 1989 to 31.1 deer/km^2 in 1993. Average density from 1962–1992 was 33 deer/km^2. Population fluctuations may be more prominent in

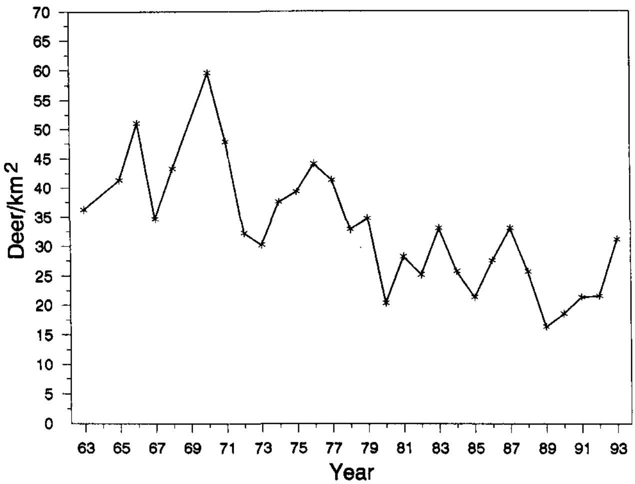

Figure 1. White-tailed deer densities on the Welder Wildlife Foundation from 1963–1992.

this herd because natural conditions are the main limiting factor. Variability in aerial censuses also account for some of the fluctuations.

According to the studies, breeding on the WWF begins as early as 13 October and ends as late as 21 February. However, 75% of the breeding occurred in November (Table 1). Mean date of conception was 22 November. Timing of conception was affected by age. Average dates of conception for fawns, yearlings, and adults were 6 December, 26 November, and 21 November, respectively. Physiological condition also has been reported to affect timing of conception; however, KFI and conception date were not correlated (r = 0.04, P = 0.38). Fawns from WWF were born from 1 May to 8 September, with a mean date of birth of 10 June. Fawns were born in May (11%), June (77%), July (11%), and August (1%). Pregnancy rates for fawns, yearlings, and adult does were 5%, 90%, and 95%, respectively (N = 943). Corpora lutea averaged 1.39 (N = 109)

Table 1. Distribution of conception dates of white-tailed deer determined by embryo measurements from 1961–1992 on the Welder Wildlife Foundation.

Month	*N*	%
Oct	19	2
1–15 Nov	228	30
16–30 Nov	346	45
1–15 Dec	131	17
16–31 Dec	30	4
Jan	12	2
Feb	3	<1

Table 2. Average eviscerated carcass weights (ECW), corpora lutea, and embryos by age class for white-tailed deer on the Welder Wildlife Foundation from 1961–1992. Corpora lutea and embryos were reported for pregnant females.

Age[a] class	ECW (kg)	SE	*N*	Corpora lutea	SE	*N*	Embryos	SE	*N*
Fawn	16.1	1.92	32	1.4	0.29	5	1.2	0.24	5
1	26.4	0.75	144	1.39	0.07	109	1.28	0.04	136
2	29.5	0.54	212	1.7	0.04	163	1.6	0.04	210
3	30.4	0.63	186	1.86	0.05	142	1.67	0.04	177
4	30.6	0.83	115	1.91	0.05	103	1.76	0.04	119
5	30.7	1.02	61	1.83	0.07	60	1.73	0.06	67
6+	30	0.85	80	1.85	0.06	66	1.75	0.06	89

[a]Fawn, 0–12 months; 1 year old, 13–24 months; 2 years old, 25–36 months; 3 years old, 37–48 months; 4 years old, 49–60; 5 years old, 61–72; 6+ years old, ≥73 months.

for yearlings and 1.83 (N = 565) for adults. A 92% fertilization rate was found for mature does and 91% for yearlings. The high fertilization rates may be related to timing of collection. Deer collected at a later date would have only the corpora lutea necessary to maintain present embryos and others could have been absorbed and not visible. There were 1.28 and 1.68 embryos/yearling and mature doe, respectively. Analysis using Tukey's studentized range test found a significant difference (P = 0.05) between yearling and adult age classes and number of embryos/doe. Reproductive potential seems to increase with age (Table 2), but no significant differences were found between adult age classes.

Barron and Harwell (1973) reported a pregnancy rate of 86% and found an average of 1.85 corpora lutea and 1.59 embryos for adult white-tailed does from the Rio Grande Plains. The fertilization rate was 88% and an average of 1.32 and 1.52 embryos were found for yearling and mature does in the Texas hill country (Teer et al. 1965).

Total fetal sex ratio on WWF was 109 males to 100 females or 52% males (N = 1199). Fetal sex ratio in yearlings was 91 males to 100 females or 48% males (N = 151). In adults there were 112 males to 100 females or 53% males (N = 1,048).

Yearling and mature does produced twins in 25% and 60% of the sample, respectively. Combining yearling and mature doe age classes, 55% carried twin or triplet embryos, 38% carried a single embryo, and 7% were barren. Only fifteen of 943 does (1.6%) averaging 4.0 years of age carried triplets. Kie and White (1985) reported 9 does with an average age of 4.4 years carrying triplets.

Data analysis using paired t-tests indicated that does on the WWF in the high weight category in age classes 1, 2, 3, and 6+ had significantly ($P \leq 0.03$) more embryos (Table 3). Data agree with Ozoga and Verme (1982) who found that low weight yearlings did not carry as many embryos as higher weight yearlings. Only yearling does in the high KFI category had significantly (P = 0.0001) more embryos than does in the same category with low KFI. Does in the high KFI category regardless of age class had significantly more embryos, 1.61 com-

Table 3. *T*-test of average fetal rates of white-tailed deer divided into high and low eviscerated carcass weights (ECW) and kidney fat index (KFI) for 6 age classes. Sample sizes (*N*) are in parenthesis.

Age class	ECW					KFI				
	High[a]	SE	Low[a]	SE	*P*	High[a]	SE	Low[a]	SE	*P*
1	1.26 (58)	0.08	0.83 (51)	0.07	0.0001	1.48 (31)	0.11	0.79 (33)	0.08	0.0001
2	1.67 (87)	0.06	1.35 (85)	0.07	0.0004	1.63 (59)	0.08	1.44 (61)	0.07	0.09
3	1.62 (76)	0.08	1.36 (80)	0.08	0.02	1.65 (48)	0.12	1.53 (47)	0.1	0.45
4	1.65 (46)	0.1	1.52 (48)	0.09	0.34	1.64 (33)	0.11	1.61 (36)	0.11	0.87
5	1.70 (24)	0.11	1.42 (26)	0.13	0.11	1.62 (13)	0.18	1.43 (14)	0.2	0.50
6+	1.73 (34)	0.1	1.40 (37)	0.11	0.03	1.76 (21)	0.15	1.38 (24)	0.13	0.06

[a]Median ECW and KFI for each age class were determined and those below the median were placed in the low ECW or KFI category. Those above the median were placed in the high ECW and KFI category.

Table 4. Pearson correlation coefficients (*r*) between number of embryos, density, age, eviscerated carcass weight (ECW), kidney fat index (KFI), and density for white-tailed deer collected on the Welder Wildlife Foundation from 1961–1992. Fawns were not included in the analysis.

	Embryos			Density		
	r	P	*N*	r	P	*N*
Age	0.42	.0001	943	—	—	—
ECW	0.60	.0001	720	−0.26	.0001	829
KFI	0.25	.0001	452	−0.25	.0001	523
Den	−0.12	.0006	894	—	—	—

pared to 1.39 ($P = 0.0006$, $N = 419$), than those in the low KFI category. Mean age for does in the low KFI group was 47 months and 44 months for does in the high KFI group. The similarity of mean age for the 2 groups indicates that the low KFI category was not heavily weighted toward younger age classes that could have biased the fetal data.

Number of embryos/doe was positively correlated with age, KFI, and ECW (Table 4). KFI and ECW data indicate that deer in better condition produced more embryos. Although the correlation coefficient was low, data indicated a negative correlation between number of embryos and population density. Also, ECW and KFI were inversely related to density, although the correlation coefficients were low (Table 4).

There was no significant difference when comparing pregnancy rates with years of above and below average rainfall using adult deer ($P = 0.905$) or yearlings and adults ($P = 0.92$). However, number of embryos was significantly different in adult deer ($P = 0.037$) and yearlings and adults ($P = 0.039$). This indicates that does will produce embryos even in years of below average rainfall although some reduction in number of embryos may be expected.

Discussion

Population densities have shown a downward trend on the WWF; however, they remain high in comparison to an 18-year average of 7.2 deer/km^2 in the South Texas region (Texas Parks and Wildl. 1992) and 11 deer/km^2 on a hunted ranch (Adams 1983) in the vicinity of WWF. Densities of 35.6 deer/km^2 reported by Teer et al. (1965) for the Llano Basin were similar to the long-term average of the WWF. Hellickson (1991) conducted trials to determine carrying capacity in 1 habitat type on the WWF and calculated a mean carrying capacity of 70 deer/km^2. This indicates that habitat and forage conditions were present to maintain densities in excess of 16.3 deer/km^2 on a long-term basis. A 3-year drought was 1 factor which caused the above-mentioned low density. Kie et al. (1980) and Kie and White (1985) showed that densities reaching 81 deer/km^2 on WWF resulted in dietary changes, reduced body weights, reduced reproduction, and a population crash. There is general agreement that increased densities and poor nutrition result in reduced body weights. Dressed weights of female deer from a high density population from the Llano Basin were 3.6–5 kg lighter than deer from the WWF from the same age class (Teer et al. 1965), indicating nutritional conditions may be higher on the WWF. Although habitat conditions could have maintained high population levels, data indicate that body weights were density dependent.

Harwell and Barron (1975) reported 71% of conception dates occurred in December and 24% occurred in January for deer from the Rio Grande Plains of Texas. From a geographic standpoint, longitude of the Rio Grande Plains is similar to the WWF, although rainfall and vegetation differ. Jacobson et al. (1979) reported over 80% of the breeding occurred between 21 December and 21 January and suggested that intensive harvest of bucks prior to peak breeding may delay breeding dates.

Pregnancy rates for fawns on the WWF were low. This may be a result of high densities. Bunnell (1987) suggested that if adult pregnancy rates are high, young animals need not reproduce unless juvenile mortality rates are high. Environmental effects on reproductive features would occur first on the youngest age classes, and then in mean litter size of adults (Bunnell 1987). Decreases in conception rates and ovulation rates occurred as densities increased (Teer et al. 1965). Jacobson et al. (1979) found that yearlings averaged 1.62 corpora lutea and 1.40 fetuses and adults averaged 1.78 corpora lutea and 1.66 fetuses. Adult averages were similar; however, WWF yearlings averages were lower which may be related to density. Comparison of pregnancy rates, corpora lutea, and number of embryos with other areas in Texas indicate that data from WWF are similar or higher. These data indicate that even at relatively high densities deer continue to produce at a high rate and number of corpora lutea and embryos are density-dependent.

Kie and White (1985) reported differences in reproductive rates between 2 populations on WWF: a population inside an exclosure in which predation was removed and densities doubled and a population outside the exclosure that had no predator control and densities remained lower than those inside the exclosure. Data from inside the exclosure were collected from 1974 to 1981. Data from outside were compiled from 1962 to 1981. Yearling does inside the exclosure produced 0.88 corpora lutea, 0.86 embryos/doe, and had a 67% pregnancy rate compared to yearling does outside the exclosure that produced 1.37 corpora lutea, 1.18 embryos, and had an 88% pregnancy rate. Mature does inside the exclosure produced 1.49 corpora lutea, 1.17 embryos, and had an 86% pregnancy rate compared to mature does outside which produced 1.95 corpora lutea, 1.6 embryos, and had a 94% pregnancy rate. Although pregnancy rates decreased about 8% in adults, a larger decrease (27%) was seen in numbers of embryos during times of high density.

Rainfall should be an indicator of the quantity and quality of forage available and was analyzed to determine if certain periods of rainfall were more important than others, especially on reproductive performance. Hellickson (1991) indicated that differences in carrying capacity between trials were a result of differences in biomass and precipitation. Verme (1969) found that nutritional level influences number of embryos/doe and suggested that reproductive performance may vary within a geographic region because of microclimate variations. Teer et al. (1965) reported population densities were related to precipitation of the previous year because of a lag in the response of vegetation to precipitation. Available forage should influence body condition and thus pregnancy rates and number of corpora lutea and embryos. WWF data indicate that during years of below average rainfall, pregnancy rates do not change significantly compared to years of above average rainfall. However, number of embryos showed an increase during years of above average rainfall. This suggests there is some reduction in reproductive potential, but does will continue to produce fawns even though condition and habitat may decline. The WWF deer herd also showed that at relatively low densities, an increase in density can occur quickly in an unhunted situation.

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