

Effects of Senescence on Female White-tailed Deer in Illinois

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ABSTRACT

The fecundity and annual survival of 26 marked white-tailed deer (*Odocoileus virginianus*) between 8 and 18 years old were examined on 2 areas in Illinois offering some refuge protection. These females, often dominant members within the deer social structure, were healthy and productive well into old age. Fawn production declined somewhat with age ($P = 0.02$), but regression analysis did not reveal an obvious inflection point. Female survival after age 8 was significantly lower than survival of these same females 3–7 years old on the same study areas. A regression curve indicated survival began a significant decline at about age 10.

INTRODUCTION

The onset of senescence and the maximum recorded life span seems to relate to the age at maturity for many birds and mammals (Ricklefs 2010). For female white-tailed deer, body mass maturity occurs at about 3 years and maximum old age at about 20 years (Ditchkoff 2011). Verme and Ullrey (1984) reported 3–7 years of age as the prime years for female white-tailed deer physical condition and fecundity after which both attributes begin a gradual decline to death. Female deer in Illinois tend to survive past age 7 years because of hunter's reluctance to kill antlerless deer and the presence of many refuges from hunting throughout the state (Roseberry and Klimstra 1974, Nixon et al. 1991). While females ≥ 8 years old make up only a small portion of any deer population, they often contribute years of experience as matriarchs, benefiting offspring of both sexes (Ozoga et al. 1982, Mech et al. 1991, Nixon et al. 2010).

Few studies have examined the effects of senescence on individual females. Dusek et al. (1989) found in Montana that natural mortalities (disease, predation, malnutrition) were higher for females ≥ 8 years compared to younger females. Other studies have refuted the contention that declines in health and fecundity is rapid after age 7, demonstrating that females remain healthy and productive well beyond this age (Masters and Mathews 1990, Nelson and Mech 1990, DelGiudice et al. 2007). Supplementally-fed older females in Michigan (Ozoga 1987) and Maine (Palmer 1951) were reported to produce 2 or 3 fawns per year through age 15. We report on the fecundity and survival

of females 8–18 years old marked on 2 areas in Illinois.

METHODS

Females were captured using rocket fired nets (Hawkins et al. 1968) between 1980–1993 on study areas located in Piatt (2,953 ha) (east-central) and DeKalb (1,648 ha) (northeast) counties in Illinois. Formal approval of deer capture procedures was not required for the years this study was conducted. Both areas featured both public and privately owned lands with year-round cover 25% and 36% and crop fields 59% and 64% of the total area on the DeKalb and Piatt areas, respectively. Both areas contained some refuge from hunting [600 ha (all of the public land) on the Piatt area and 287 ha (60% of the public land) on the DeKalb area]. The public land in the DeKalb area was hunted by archers only. The remaining areas on both study sites were hunted by both archers and shotgun hunters.

Females were manually restrained and aged at capture as fawn (< 12 months), yearling (13–24 months), 2 years (25–36 months), or adult (> 36 months) based on tooth wear and replacement observed on live deer (Severinghaus 1949). All females used for this study were < 36 months old when captured and thus were considered known aged. Females were marked using radio collars ($N = 13$) or plastic collars ($N = 13$) bearing reflective numbers or letters for ease of identification. Radio-marked females were located 2–4 times per week using 2 truck-mounted, 8-element yagi antennas aligned in a null configuration. The females without radios used for this study

were observed frequently ($>$ once per week and for some females almost daily). In addition, radio-marked females were deliberately approached in late summer to ascertain the presence of living fawns.

For this study, we used 26 females that reached at least 8 years of age. For these females we recorded offspring recruitment to weaning age (1 Oct) for the years 3–17 years. Because fawn observations were often not possible until early fall (because of fawn hiding behavior) early fawn losses were not detected, and the fawn production reported here must be considered a conservative estimate of fecundity. For many females we did not know fawn production for every year because when females were observed, they were part of large groups of females or else were alone during fall and winter. We used fawn production as the independent variable in a regression analysis for the ages 3 to 17 years.

The actual date of death was obtained for 14 of the 26 females. Deer whose death could be not be verified were considered missing from the study areas when they no longer were observed or radio-tracked. As older females are very site habituated (Teirson et al. 1985, Dusek et al. 1989, Nixon et al. 1991) disappearance for these females almost certainly meant death. These deer were recorded as censored for the purpose of survival analysis. As individual deer died or went missing during a given year, those remaining became the next year's cohort. Annual survival was calculated using the efficient score method (corrected for continuity) described by Newcombe (1998). For

a regression analysis of age and survival, we used the female survival rates for ages 3–7 years reported in an earlier publication (Nixon et al. 2001) for females on the same study areas and used the data reported here for ages 8–18 years. Although both the fawn/doe ratios and survival rates were slightly different from normal by the Shapiro-Wilks test (both were $P = 0.02$), the data contained tied values that can adversely affect the Shapiro-Wilks test (Zar 1999). The mean fawn/doe ratio was $1.8 \pm SE 0.08$, and the mean survival rate was $0.42 \pm SE 0.05$. Based on this level of dispersion and their graphical distribution, they were deemed acceptable for use in a linear regression test. Also, the data were randomly sampled and independent.

The social position was known for 23 females and was based on dyad encounters won or lost, leadership within a social group, and in winter, leadership of large (up to 80 deer) mixed sex groups seen on both study areas. These dominant females were known to recruit more fawns and to live in large secure (from hunters and other predators) home ranges compared to subordinate females (Nelson and Mech 1999, Nixon et al. 2010).

RESULTS AND DISCUSSION

Known aged females ranged from 26 at aged 8 years to 1 female known alive at age 18 (Table 1). Regression analysis of age

Table 1. Fecundity and survival of 26 old-aged female white-tailed deer that survived to ≥ 8 years old marked on study areas located in Piatt and DeKalb counties in Illinois, 1980–93. Fawn production represent fawns observed postweaning.

Age (yrs)	Productivity				Survival		Survival Rate
	Total Females	Females with Known Fawns	Total Fawns	Fawns per Female	Known Deaths	Unknown Fate	
3	26	20	42	2.10	0	0	n/a
4	26	20	44	2.20	0	0	n/a
5	26	20	43	2.15	0	0	n/a
6	26	17	30	1.76	0	0	n/a
7	26	13	24	1.85	0	0	n/a
8	26	17	30	1.76	7	0	0.73
9	19	7	14	2.00	4	0	0.57
10	15	4	7	1.75	1	2	0.54
11	12	3	6	2.00	3	0	0.40
12	9	2	3	1.50	0	0	0.40
13	9	3	6	2.00	1	1	0.36
14	7	2	4	2.00	1	2	0.31
15	4	1	2	2.00	0	1	0.31
16	3	1	1	1.00	0	1	0.31
17	2	2	3	1.50	0	1	0.31
18 ^a	1	unk	unk	unk	unk	unk	0.31

^aFawn production was unknown for this female, but she was still alive the conclusion of the study.

and fawn recruitment was significant ($R^2 = 0.33$, $F = 6.36$, $df = 1,13$, $P = 0.02$) showing a gradual decline in the number of weaned fawns but the regression curve did not reveal an inflection point where fawn recruitment began a steady decline (Fig. 1). Our data indicated that Illinois females continued to breed well into old age. McCullough (1979) believed that old females remain productive until death because they have little expectation of further life and a breeding foregone at these ages is lost forever.

Mean annual survival averaged 0.42 (SE

$= 0.05$) for these older females and was considerably lower than survival rates of females 3–7 years old calculated for all females (average of 0.80 [± 0.13 , 95% C.I.] and 0.81 [± 0.15 , 95% C.I.] for Piatt and DeKalb counties, respectively) (Nixon et al. 2001). The cubic polynomial regression produced a curve with an inflection point at about age 10, when survival began a rapid decline ($R^2 = 0.94$, $F = 55.01$, $df = 3,11$, $P < 0.0001$) (Fig. 2). Death from hunting was the leading cause of mortality for these older females, as is the case for younger deer as well (Nixon et al. 2001).

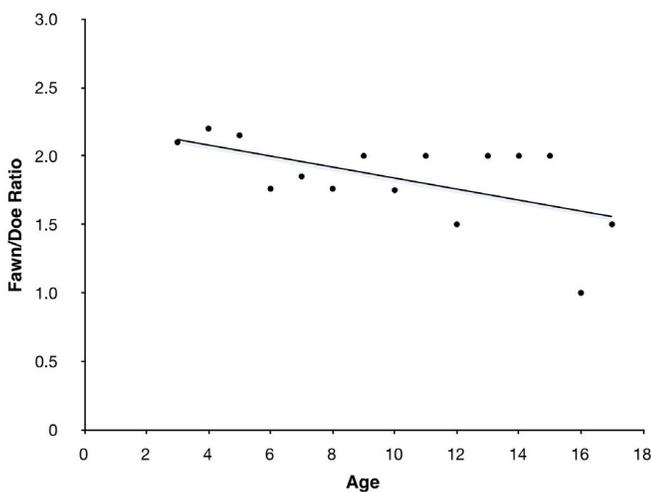


Fig. 1. Linear regression plot of fawn/doe ratios by age of producing female white-tailed deer marked on study areas located in Piatt and DeKalb counties in Illinois, 1980–93. Fawn production represent fawns observed postweaning.

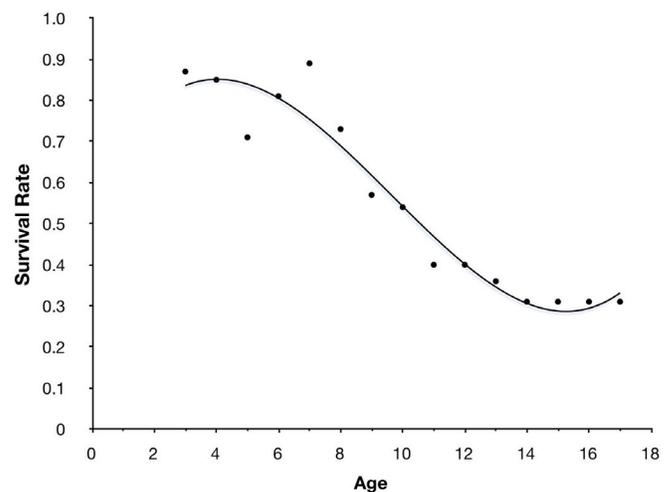


Fig. 2. Polynomial (cubic) regression plot of survival rate by age of female white-tailed deer marked on study areas located in Piatt and DeKalb counties in Illinois, 1980–93. The points for ages 3-7 represent the mean survival rate for all females for both study areas (Piatt: Nixon et al. 1991; DeKalb: unpublished data).

Social position also affected longevity. Six of 7 subordinate females died between 8 and 10 years after birth, and 4 of the 6 deaths were due to vehicle collisions. Dominant females survived considerably longer, and only 1 died as a result of highway accident. The social status for 3 females was unknown. Unlike younger females, dominant females were reported to time road crossings to avoid traffic in the Chicago metro area and were seldom hit by vehicles (Etter et al. 2002). Of 16 known dominant females, 4 died during their 8th year, 2 died at 9, 2 at 10, 3 at 11, and 1 each for years 13, 14, 15, and 17. On our study areas these dominant females established home ranges that, for the most part, avoided dangerous situations, contained abundant forage opportunities, and supported large social groups (Nixon et al. 2010).

CONCLUSIONS

In Illinois, where females have at least partial refuge protection from hunting, evidence seems to indicate that they often achieve old age and remain productive. Females on our study areas were in good physical condition based on fecundity, general appearance, and general behavior when observed. With no particular environmental stresses early in life (such as severe winters or constant predator pressures), the females marked during this study would likely not experience early onset of senescence and would be expected to survive well past the prime years (Metcalf and Monahan 2001, Nussey et al. 2007). In addition, females have more molar teeth surface area per unit mass than do males, which allows for increased mastication and faster food passage. Female teeth show less wear than males and thus provide feeding opportunities later in life allowing females to remain healthy and reproductive into older age (Van Deelen et al. 2000).

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