

REPRODUCTIVE PERFORMANCE OF FEMALE KEY DEER

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Abstract: The reproductive performance of the endangered Key deer (*Odocoileus virginianus clavium*) is a potential limiting factor in its conservation. We analyzed data collected by necropsy of 142 female Key deer from 1968 through 1989 to provide a better understanding of their reproduction. A breeding season of about 6 months was longer than for more northerly herds of white-tailed deer. Productivity of Key deer was low (0.76 fetuses/F ≥ 1 yr of age at breeding) and fetal sex ratio (74% M) was high for the species. Rates of reproductive activity (% pregnant or lactating) for females at age of breeding were 4% for fawns, 58% for yearlings, 61% for ages 2–4 years, and 90% for females ≥ 5 years of age. Eight (17%) of 48 pregnant females carried twins, and the remainder carried single fetuses. We hypothesize that poor reproductive performance of female Key deer is due to a nutrient deficiency or that it evolved as an adaptation to an insular habitat.

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The endangered Key deer of the lower Florida Keys are smallest in mass of the subspecies of North American white-tailed deer (Hardin et al. 1984) and are isolated from mainland Florida by 60 km of water. Prior to protection from hunting, the population of Key deer declined to a low of 25–80 in 1951–52 (Dickson 1955). Klimstra et al. (1978), using spotlight surveys, estimated that the population increased to 300–400 in the early 1970's. The U.S. Fish and Wildlife Service (1985) reported a decline in population to 250–300 by 1984. Low reproductive output apparently contributed to the slow recovery of the Key deer population from the low of the early 1950's (Hardin 1974). Currently, development encroaching on habitat (U.S. Fish Wildl. Serv. 1985) and mortality due to collisions with automobiles result in a precarious status for the Key deer population.

Nutrition, one of the most important factors affecting productivity of white-tailed deer (Verme 1967, McCullough 1979), affects both ovulation rate and the proportion of females that become pregnant (Sadleir 1987). An imbalanced ratio of calcium (Ca):phosphorus (P) or deficiencies of cobalt (Co), iron (Fe), or copper (Cu) probably contribute to low productivity of white-tailed deer from the southeastern United States (Smith et al. 1956, Harlow 1972, Smith and Hunter 1978). The diet of Key deer may be deficient in P (Widowski 1977) or other nutrients, forcing females <4 years old (that have not reached peak mass) to concentrate energy and nutrients on body growth rather than re-

production. We analyzed long-term data collected from mortalities of female Key deer to indirectly test this hypothesis.

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STUDY AREA

Key deer occupy a group of islands from 8 to 2,400 ha (\bar{x} = 340 ha) in an area southwest of Miami (Hardin et al. 1984:Fig. 83). Key deer apparently were isolated from mainland populations about 4,000 years ago by rising sea levels during melting of the Wisconsin Glacier (Hoffmeister 1974). The current distribution of the Key deer consists of 26 major islands separated by up to 2.3 km (\bar{x} \approx 1.1 km). Key deer travel between islands, especially in response to availability of drinkable water (Klimstra et al. 1981). Vegetation of the lower Keys is predominantly of West Indian origin (Klimstra et al. 1981), and habitat quality differs greatly between and within islands. Vegetation of the lower keys and habitat used by Key deer have been described (Dickson 1955, Silvy 1975, Hardin et al. 1984).

METHODS

Data for describing chronology of reproduction were obtained by necropsy of 295 female

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Key deer from 1968 through 1989. However, only animals collected during the months of January–June ($n = 142$) were included in statistical analyses because >90% of breeding activity is completed by January (Hardin 1974), and reproductive status—pregnant, lactating (determined by presence of milk in udder), or barren—could be determined with minimal error during this interval. We could not eliminate the potential for bias of productivity estimates because barren females collected early in the year could have recently bred or could have bred later, had they lived. In addition, females that lost fawns early but were collected late in the fawning season might have appeared barren during necropsy. Most (95%) deer included in analyses had been killed in collisions with vehicles. Reproductive status was determined for each female; the number and sex of fetuses were also recorded if possible. We excluded animals from analyses if their reproductive status was questionable. We estimated ages of Key deer by eruption and wear of teeth (Severinghaus 1949) because it was more accurate than use of annuli counts (Maffei et al. 1988). Deer collected from 1968 through 1985 were aged by a team of 4 deer biologists at an “aging bee,” while those collected after 1985 were aged at the time of necropsy. Aging accuracy was aided by reference to jaws from known-aged Key deer.

Reproduction of Key deer is less synchronized than in more northerly herds, therefore we equated percent pregnant and lactating in Key deer with rate of pregnancy in other white-tailed deer. Productivity refers to number of fetuses per female for all females examined, and fetal rate describes fetuses per pregnant female. We assigned ages assuming a birth date of 1 April (Silvy 1975). Age at breeding for deer collected April–June was determined by subtracting 1 year from the age estimate.

We used a 1-way ANOVA (GLM, SAS Inst., Inc. 1987) to compare reproductive characteristics (dependent variables) among ages (independent variables). We compared means showing significant ($P < 0.05$) variation with Duncan’s multiple range tests.

RESULTS

Pregnant females were collected in all months except September and October (Fig. 1). The greatest percentage (82%) of pregnant females was collected in March. Peak percentage (38%) of lactating females occurred in July. Both preg-

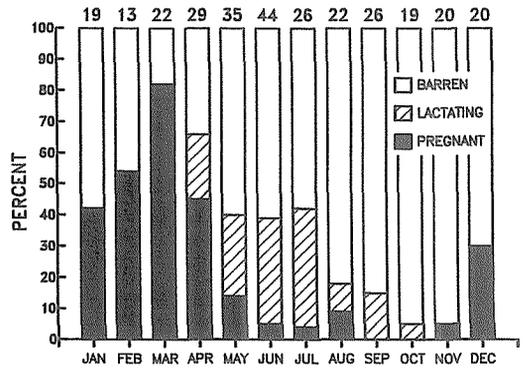


Fig. 1. Reproductive status of female Key deer ($n = 295$) collected 1968–89. Sample sizes are above bars.

nant and lactating Key deer were collected during April–August.

Single fetuses were present in 40 of 48 (83%) pregnant females; 8 (17%) carried twins, and none had triplets (Table 1). Seven of 8 incidences of twinning occurred in females ≥ 4 years of age at breeding, and 1 incidence was in a female 1 year of age at breeding. Fetal sex ratios within combined age classes were significantly skewed toward males (Table 1).

Rate of reproductive activity appeared to increase with age (Table 2). In other populations of white-tailed deer, age classes 2–4 usually exhibit a high rate of pregnancy, but only about 61% of Key deer in those age classes were reproductively active.

There were no significant differences among age-specific fetal rates, but females ≥ 4 years of age at breeding tended to have relatively large litters (Table 2). Females that bred as yearlings did not differ in fetal rate, productivity, or rate of reproductive activity from females that bred as 2-year-olds.

DISCUSSION

Our findings concur with previous Key deer studies (Hardin 1974, Klimstra et al. 1981) which found that parturition occurred mainly in April and May, but that small spotted fawns had been observed in almost every month. Breeding season for Key deer starts in September, peaks in October, and declines through December (Hardin 1974). Limited breeding activity has been observed in January and February, but about 90% of breeding activity observed in 1970–71 was completed by 22 December (Hardin 1974: 140). Breeding seasons of white-tailed deer were ≤ 4 months in the southern United States, Mex-

Table 1. Fecundity and fetal sex ratios based on necropsies of Key deer, 1968–89.

Breeding age of F (yr)	n	Single fetuses			Twin fetuses			Fetal sex ratio (M:F)	P ^a
		M	F	Unknown	M	F	Unknown		
Fawns	27	0	0	1	0	0	0		
Yearlings	31	6	0	5	1	1	0	7:1	
2	30	4	0	6	0	0	0	4:0	
3	18	3	4	3	0	0	0	3:4	
4	16	1	0	1	6	0	0	7:0	
≥5	20	1	2	3	4	2	2	5:4	
≥1	115	15	6	18	11	3	2	26:9	<0.005
≥2	84	9	6	13	10	2	2	19:8	<0.05
All	142	15	6	19	11	3	2	26:9	<0.005

^a χ^2 goodness-of-fit tests.

ico, and Central America (Roberson and Dennett 1966, Lueth 1968, White 1973, Noble 1974, Mendez 1984, Richter and Labisky 1985, Miller 1988) and from 7 to 12 months in South America (Brokx 1984, Blouch 1987). The breeding season for Key deer lasts about 6 months and appears to be longer than that of more northerly white-tailed deer herds. The range of the Key deer is at the southern-most reach of the conterminous United States, and the climate is subtropical-marine (Schomer and Drew 1982). We would expect a relatively long breeding season for Key deer because reproductive seasons for deer become less synchronous at lower temperate latitudes, apparently in response to moderate environmental pressures that allow longer fawning seasons (Branan and Marchinton 1987).

The preponderance of males (74%) among Key deer fetuses is unusually high for white-tailed deer. Verme (1967) reported 75% males in captive deer whose productivity was similar to that of Key deer. In another captive herd, Downing (1965) observed 80% males among fawns. In a sample from Cumberland Island, 68% of fetuses were male (Miller 1988).

Our estimate of a highly male-biased fetal sex ratio for Key deer is greater than that predicted by a regression of progeny sex ratio on productivity of *Odocoileus* (Verme 1983:Fig. 1). When plotted with 30 other observations from white-tailed, mule (*O. hemionus*), and black-tailed deer (*O. h. columbianus*), the Key deer observation falls just above the upper 95% confidence limit of the regression equation. Only 1 of 30 of the observations of sex ratio was greater than that of Key deer.

Typical of the species, yearling male Key deer disperse from their natal ranges (Silvy 1975). When food supply is limiting within the maternal home range, fitness of female Key deer

would be enhanced by producing males, which through dispersal may encounter better habitat (McCullough 1979). Dispersal also minimizes inbreeding (Cothran et al. 1983), which may be especially important for the small, geographically limited Key deer population.

Reproductive characteristics of Key deer were compared with those from a generalized sustained yield table for white-tailed deer (Downing and Guynn 1985). In the table, lowest values for productivity (0 fawns/yearling and 0.9 fawns/ad) and highest value (58% M) for fawn sex ratio occurred at maximum sustained density. Based on comparable values for Key deer of 0.04, 0.76, and 74%, respectively, it appears that Key deer have an unusually low reproductive potential and probably are near carrying capacity.

We are aware of no published rates of productivity in free-ranging white-tailed deer of North America lower than those we estimate for Key deer, but in 2 other insular populations, rates of productivity were similar. Osborne (1976) reported 1.11 fetuses per pregnant female ($n = 27$) ≥ 2 years old (vs. 1.20 for Key deer) but estimated the rate of pregnancy as 90% (vs. 68% for Key deer) on Blackbeard Island, Georgia. Miller (1988) reported 1.06 fetuses per pregnant female ($n = 50$) ≥ 1 year old (vs. 1.17 for Key deer) on Cumberland Island; however, prevalence of pregnancy was 100% (vs. 65% for Key deer). Therefore, despite low fetal rates in these 2 insular populations, they realized greater net productivity for a given number of females than Key deer because of high rates of pregnancy.

Many of the 164 species of food plants used by Key deer (Klimstra and Dooley 1990) contained gross energy values comparable to commercial feeds (Morthland 1972), and Donvito

Table 2. Age-specific productivity, based on necropsies, of female Key deer, 1968–89.

Breeding age (yr)	n	No. pregnant	No. lactating	Total fetuses	\bar{x} fetuses/all F ^a	\bar{x} fetuses/pregnant F	% pregnant or lactating F
Fawns	27	1	0	1	0.04 A ^b	1.00 A	4 A
Yearlings	31	12	6	13	0.63 B	1.08 A	58 B
2	30	10	6	10	0.53 B	1.00 A	53 B
3	18	10	3	10	0.72 BC	1.00 A	72 BC
4	16	5	5	8	1.00 CD	1.60 B	63 B
≥5	20	10	8	14	1.26 D	1.40 AB	90 C
≥1	115	47	28	55	0.76	1.17	65
≥2	84	35	22	42	0.81	1.20	68
All	142	48	28	56	0.62	1.17	54

^a [total fetuses + (no. lactating × \bar{x} fetuses/pregnant F)]/n.

^b Means within columns followed by the same letter are not significantly different ($P > 0.05$).

(1979) found no evidence of a lack of digestibility in Key deer food plants. Widowski (1977) reported, however, that vegetation on Big Pine Key was relatively high in Ca and low in P, and suggested that this may be negatively affecting Key deer productivity. The most frequently observed problem associated with a deficiency of P is irregularity or cessation of estrus (Maynard et al. 1979). Therefore the low rate of reproductive activity we observed in Key deer supports the hypothesis that P is limiting. Unfortunately, we do not know the proportion of females in this population that achieve estrus.

Key deer evolved in a unique island setting with relatively little influence from disease and predation (Klimstra et al. 1981). Given the distinct limitation of space of this population, Key deer may benefit from a male-biased fetal sex ratio and low rate of productivity. Our findings of a delayed peak of reproductive potential are consistent with the hypothesis of a nutrient deficiency. However, the hypothesis that their low reproductive performance is a genetically fixed adaptation should be tested in future research.

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