Periodic Observations on an Unhunted South Carolina Deer Herd: 1976–1989

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Abstract: Periodic observations from 1976 through 1989 on an unhunted white-tailed deer (*Odocoileus virginianus*) herd located in coastal South Carolina indicated that the population had likely incurred a major decline from a hemorrhagic disease (HD) outbreak, and another may be imminent. Weights of adult does were comparable to those of the hunted herd on the nearby Francis Marion National Forest. Conception rates were insensitive to the occurrence of HD or acorn mast failures. Among adult does collected in early February, femur marrow fat content was a better indicator of animal condition and the abundance of acorns during the previous fall than perirenal fat or serum cholesterol levels. Significant ($P < 0.05$) differences in blood urea nitrogen and albumin concentrations seemed to be negatively associated with prevalence of HD and positively associated with fall acorn abundance. Significant ($P < 0.05$) differences in bilirubin and lactic dehydrogenase concentrations seemed to be positively associated with prevalence of HD.

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Opportunities to monitor natural changes in an unhunted, free-ranging white-tailed deer herd are rare, but such information can be helpful in understanding the biology of the species. Limited opportunities to gather information on such a herd on Hobcaw Barony Plantation in coastal South Carolina were available from 1976 through 1989.

Deer hunting on this area ceased in the mid-1940s and a no-hunting philosophy and policy was continued when the Belle W. Baruch Foundation assumed trusteeship of the property in 1964. A major deer die-off reportedly occurred over a span of 3 years in the mid-1960s (E. A. Severin, pers. commun.). Evidence collected in surveys for deer skeletal remains in 1974 suggested that a considerable amount of poaching had occurred in the late 1960s and early 1970s (G. W. Wood, unpubl.

data). In 1974 the herd received substantially increased protection from poaching, and subsequent increases in density seemed obvious.

In 1976, recognition of the unlikelihood that the herd was in a state of sustained equilibrium led to an agreement between Clemson University and the Baruch Foundation to periodically gather information relative to changes in deer density, nutritional condition, and reproductive status. Specific objectives were to measure changes in: 1) herd density as reflected by a standardized spotlight survey, 2) nutritional condition as reflected by live weights and fat deposition in adult does, and 3) conception rates among adult does. In 1981, studies of changes in serum chemistry were begun in order to gain further insight into nutritional condition. In addition, observations of disease incidence in the herd were begun by serological monitoring.

Study Area

Hobcaw Barony is a 7,000-ha plantation located about 3 km east of Georgetown, South Carolina. It is at the end of a peninsula known as the Waccamaw Neck and is bounded to the west and south by Winyah Bay and to the east by the Atlantic Ocean. About 3,000 ha are forested, 3,000 ha are saltmarsh; and 1,000 ha are freshwater, brackish marshes, and abandoned ricefields.

About 61% of the forest is in pine stands with 22% in loblolly pine (*Pinus taeda*), 21% in longleaf pine (*P. palustris*), and 18% in mixed pine. Pine-hardwood stands make up 20% of the forest cover, and upland hardwoods account for 11%. Cypress-gum (*Taxodium-Nyssa*) stands account for 5% of the area and open fields for 3%. The area has about 128 km of roads that provide excellent access to all upland areas.

Methods

The spotlight surveys used in the study from 1976 through 1982 were described by Wood et al. (1983). We made counts along a standardized 28-km route on 8 nights during the first 3 weeks of December each year. Spotlight surveys were discontinued from 1983 through 1986 for administrative reasons. They were repeated in 1987 and 1988 with modification necessitated by limitations in available personnel. The modification consisted of using 1 crew to run a 17-km route as a replacement technique for 2 crews, each running one-half of a 28-km route.

Animal collection by shooting over spotlights was begun in January 1977. Subsequent to several observations of breeding behavior in January, the collection period was changed to the first 2 weeks of February. The total size of the collection was limited administratively to 12 animals per period in 1977, 1981, and 1983; 9 in 1988; and 10 in 1989. Antlerless bucks and large fawns were occasionally mistaken for adult does and had to be included in the limited total. All animals were shot in the head or upper neck.

As soon as each animal was shot, 2 15-cc vacutainers were filled with blood from the heart and held for 2 to 3 hours at ambient temperature (typically 4°–6° C). The serum was separated by centrifugation and stored at −5° C to await laboratory analysis. Standard SMA–12 serum chemistry profiles were contracted to a commercial laboratory being used by local veterinarians. The profile included: Ca, P, glucose, blood urea nitrogen (BUN), cholesterol, total protein, albumin, bilirubin, uric acid, lactic dehydrogenase (LDH), serum glutamic oxalacetic transaminase (SGOT), and alkaline phosphotase.

Serological tests for disease antibodies were submitted to the National Veterinary Services Laboratory through Clemson University. Tests for antibodies for bluetongue (BT) and epizootic hemorrhagic disease (EHD), collectively referred to as hemorrhagic disease (HD) (Thomas 1981), were made in 1981, 1983, 1988, and 1989. In 1981, because of a substantial incidence rate for brucellosis (Wood et al. 1976) and pseudorabies in feral swine (G. W. Wood, unpubl. data) on Hobcaw, tests for antibodies for these diseases also were made.

Carcasses were processed within 2 to 3 hours of collection. Age determinations up to the fourth year were made by dentition (Severinghaus 1949). Animals ≥4 years old were combined into 1 age class. Each animal was weighed and then eviscerated. The reproductive tract was examined and crown-rump lengths and weight of each fetus were determined. Since Verme and Ullrey (1984) had warned that physical measurements of fetuses should not be used to establish conception dates, this procedure was not attempted.

The perirenal fat deposit was measured by first drawing an imaginary square framing the kidneys and allowing about 2.5 cm clearance from the kidney tissue. The kidneys with the fat from this zone were excised and cooled to ambient temperatures. This procedure was done consistently by the senior author throughout the study. The fat was stripped from the kidneys and weighed.

Both femurs were extracted and frozen. We removed and refroze the center one-third of the longitudinal section of each femur and delivered these to the Clemson University Agricultural Chemical Services Laboratory. Percent moisture in the marrow was determined by freeze-drying. Percent crude fat was determined by ether extraction and expressed as a percentage of freeze-dried weight.

Because of small and unequal sample sizes, the Kruskal-Wallis 1-way analysis of variance (Kruskal and Wallis 1952) was used to test for differences in sample group characteristics between years. When the test indicated a significant ($P < 0.05$) difference among years, individual means were tested against 1 another by t-tests for unpaired, unequal sample sizes (Steel and Torrie 1960).

Results and Discussion

Herd Density

Wood et al. (1983) discussed the detected changes in deer densities from 1976 through 1982 (Table 1). While the route used for the 1987 and 1988 surveys was only 64% of the former route, 80% of the new route was in common with the old one. Both routes were designed to transect all vegetation types in the approximate

Table 1. Estimated deer densities in December 1976–82 and 1987–88 on Hobcaw Barony Plantation, South Carolina.

Year[a]	Deer density (N/40 ha)	
	$\bar{X}$[b]	Range
1976	8.9	2.7–18.1
1977	9.3	5.0–13.6
1978	8.9	3.2–13.3
1979	14.0	9.4–17.3
1980	10.2	3.6–17.3
1981	9.3	4.7–15.7
1982	8.4	0.4–12.8
1987[c]	17.8	11.8–23.9
1988[c]	12.6	7.7–16.7

[a]Years 1976–1982 from Wood et al. (1983).
[b]Based on 8 counts using the Gates perpendicular distance method (Wood et al. 1983).
[c]Survey method changed (see text).

proportion in which they existed on the study area. Therefore, we assumed that the results from the different survey techniques were generally comparable.

The data indicated that the Hobcaw herd increased rapidly through the late 1970s. In 1980 an outbreak of hemorrhagic disease (HD) began and continued through 1982. Detected densities of deer decreased sharply during those years. The perception of actual changes in the population may have been biased since we knew that many deer were affected with severe laminitis from HD and consequently had limited mobility. Low levels of movement activity were certain to erroneously reduce any population density index based on animal sightings.

The detected density of deer in December 1987 suggested that the herd density had returned to levels comparable to those of the late 1970s. The 1988 survey data indicated a decline in numbers of detectable deer.

Adult Doe Weights

Of 55 deer collected in the 5 collection periods, 36 were does ≥2 years old. Mean weights for 2-year-old does were 32.4 ± 3.7 (SD) kg (N = 5). Weights for the 3-year-old class (N = 7) and ≥4-year-old class (N = 24) were 41.7 ± 4.1 kg and 42.1 ± 3.6 kg, respectively. The 2-year-old class was significantly ($P < 0.05$) lighter than the 3-year-old class, but the 3-year-old and ≥4-year-old age classes were not significantly different. There were no significant differences in weights among collection periods for deer ≥3 years old. The sample size for the 2-year-old class was too small to test.

Weights of adult does collected in February on Hobcaw were comparable to the average hunting season weights of adult does on the Francis Marion National

Forest for the period of 1976 through 1987 (W. E. Mayhan, unpubl. data). Mean weights by age class for the Francis Marion National Forest were: 1.5 years – 35.0 kg (N = 116), 2.5 years – 39.0 kg (N = 167), and 3.5+ years – 42.8 kg (N = 190).

Conception Rates

Conception rates among adult does were high in the Hobcaw herd (Table 2). Thirty-six adult does collected in the 5 periods were pregnant with 38 fetuses. Great variation in fetus sizes within each collection period suggested a wide range in conception dates. This was in agreement with our observations of neonatal fawns occurring in the herd from early April into August.

While we did not attempt quantitative measures of mast production, it seemed reasonable to qualitatively describe the variation as ranging from exceptionally abundant to general failure. Our finding that conception rates among adult does were insensitive to changes in acorn availability was in agreement with the findings of Wentworth et al. (in review).

Since the 1977 collection was made in early January, the weights and measurements of that collection were not comparable to those in other years. Although there were no significant differences in mean weights or weights per unit of crown-rump length among years, mean weights seemed to be declining from 1981 through 1989 (Table 2). An interesting contrast was the generally heavier weight and greater weight per unit length measures of fetuses in the 1989 collection compared to those of 1988. The latter followed an exceptionally abundant mast crop, while the former followed a general mast failure. The small sample sizes and high variability among conception dates precluded any conclusions based on these observations.

Fat Deposits

Perirenal fat was measured in 23 adult does. There were no differences in weights of this tissue among age classes or among collection periods. Only 2 does on which perirenal fat was measured were not pregnant, therefore no comparison between pregnant and non-pregnant animals was made.

Table 2. Conception rates and fetus sizes for does (≥2 years old) collected periodically in winter 1977 through 1989 on Hobcaw Barony Plantation, South Carolina.

Year[a]	N does	N pregnant does	N fetuses	Fetus weight (g) $\bar{X}$	Fetus weight (g) SD	Fetus weight (g)/ crown-rump length (cm) $\bar{X}$	Fetus weight (g)/ crown-rump length (cm) SD
1977	7	6	6	322	305	12.2	8.5
1981	9	8	10	791	514	26.9	10.6
1983	6	6	7	626	532	21.8	15.1
1988	7	6	7	371	345	15.2	11.8
1989	7	7	8	453	343	18.7	9.6

[a]Collection made in early January in 1977 and early February in all other years.

The use of perirenal fat deposition as an indicator of animal condition has been used widely. Riney (1955) first described the kidney fat index (KFI) for red deer (*Cervus elaphus*). Dauphine (1975) indicated that seasonal variation in kidney size in caribou (*Rangifer tarandus*) rendered useless the kidney weight correction factor in the KFI. He suggested that so long as comparisons were restricted to 1 age-sex class and 1 season, the simple comparison of weights of fat tissue was adequate. Similar conclusions for deer were reached by Verme and Ozoga (1980) and Kie et al. (1983). Johns et al. (1984) reported that low KFI's should be expected in warm-climate areas regardless of habitat conditions. Our experience with the Hobcaw herd indicated that perirenal fat was so variable, even within an age-sex class, that its usefulness as a condition factor was very limited.

Percent moisture in femur marrow fluctuated widely with a mean of 36.9 ± 10.7% (*N* = 32) and a range of 6.1 to 52.7%. No significant differences existed between age classes or among collection periods.

Femur marrow fat content seemed to reflect the level of acorn abundance in the previous fall and degree of stress related to disease condition. While there was no difference among age classes, when measures for all adult does were combined, the large acorn mast crops of 1976 and 1987 were followed by high levels of femur marrow fat in 1977 and 1988, respectively (Table 3). The reverse was true following general mast failures in 1980 and 1988.

Serum Chemistry

Because of the extremely variable results from analyses for uric acid, that serum component was disregarded. No differences were found between age classes of 26 does when the other 11 serum components were tested. When all age classes were combined, significant differences between collection periods were found for BUN, cholesterol, albumin, bilirubin, and LDH (Table 3). Mean ± SD concentrations (*N* = 26) for the other 6 components for all years and all age classes combined were as follows: Ca − 9.6 ± 0.5 mg/dl; P − 8.4 ± 1.4 mg/dl, glucose − 158 ± 62 mg/dl; total protein − 7.0 ± 0.9 g/dl; SGOT − 154 ± 34 IU/L; and alkaline phosphotase 45.9 ± 16.7 IU/L18. Most of these values were within the range of reference values reported by Seal et al. (1981). These authors warned that post-mortem samples taken from the heart might yield higher values for P and SGOT than would samples taken from the jugular vein. This may partially explain the relatively high values obtained for these components in this study.

Changes in serum chemistry as a reflection of changes in planes of nutrition in white-tailed deer have been studied by Seal et al. (1972), Coblentz (1975), Hartzook et al. (1975), Kirkpatrick et al. (1975), Seal et al (1978), Bahnak et al. (1979), Warren et al. (1981), Kie et al. (1983), and DelGiudice et al. (1987). Blankenship and Varner (1977) and Mautz et al. (1980) warned that factors associated with sample collection could affect blood chemistry, but most workers agree that serum chemistry can be helpful in indicating the nutritional relationship between the animal and its habitat.

Kirkpatrick et al. (1975) presented data and an extensive discussion of the

Table 3. Nutritional characteristics that showed significant differences ($P < 0.05$) among years for does ($\geq$2 years old) on Hobcaw Barony Plantation, South Carolina.

		Femur marrow fat (%)		Blood urea nitrogen (mg/dl)		Cholesterol (mg/dl)		Albumin (g/dl)		Lactic dehydrogenase (IU/L)		Bilirubin (mg/dl)	
Year[a]	N	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
1977	6	75.4B[b]	12.7	NM[c]		NM		NM		NM		NM	
1981	7	45.2A	11.8	8.7A	3.6	43.9A	6.7	2.3A	0.3	0.6A	0.1	399AB	69
1983	6	61.0AB	16.3	8.7A	4.7	48.0A	5.9	2.5A	0.2	0.4AB	1.0	426A	63
1988	6	85.9B	6.0	16.7B	6.9	55.5B	7.6	3.0B	0.3	0.3B	0.1	300C	33
1989	7	55.1A	6.8	13.6AB	6.9	52.1AB	7.7	2.9B	0.3	0.5A	0.1	330BC	49

[a]Collection made in early January in 1977 and in early February in all other years.
[b]Means within a column followed by dissimilar letters are different ($P < 0.05$; t-test).
[c]Not measured.

literature to support the use of BUN as a good indicator of protein intake by deer. DelGiudice et al. (1987) considered the warnings of Warren et al. (1982) about the variability of BUN, but arrived at the same conclusion as had Kirkpatrick et al. (1975). Seal et al. (1981) offered a reference range for BUN of 15–45 mg/dl. In 1981 and 1983 the Hobcaw herd was in a state of decline from the very high densities of the late 1970s. Competition for the generally low quality forages (Wood 1986) available in the habitat was high. The exceptionally abundant acorn crop of 1987 could have increased digestible energy and thus increased the efficiency of rumen microbial digestion of dietary protein (Kirkpatrick et al. 1975, Pekins and Mautz 1988), and thus caused the high BUN concentrations in 1988.

Albumin levels were well within the range of those offered for reference by Seal et al. (1981). It followed a pattern of change similar to that of BUN and probably was affected by the same factors.

Coblentz (1975) felt that serum cholesterol could be a good indicator of dietary digestible energy. However, Warren et al. (1981) showed that cholesterol levels were not related to levels of food intake or weight gain in adult bucks. They theorized that changes in serum cholesterol were likely to be most affected by seasonal variations in reproductive hormones in both bucks and does. The data of DelGiudice et al. (1987) pointed out that a fasted animal could sometimes catabolize enough fat to raise cholesterol levels above those of deer on a continuous high energy ration. Catabolism may explain why the difference in serum cholesterol between 1988 and 1989 does not appear comparable to the difference in femur marrow fat for these collections. Considering the vast difference between the 1987 and 1988 acorn mast crops (exceptionally abundant vs general failure), serum cholesterol level alone did not seem to be a dependable indicator of either energy availability or storage. This conclusion is in general agreement with that of DelGiudice et al. (1987).

Why concentrations of bilirubin were well above the range of reference values given by Seal et al. (1981) was not obvious. LDH levels were well within the range of reference values.

Disease Incidence

HD serological reactors have been common in the Hobcaw deer herd at least since 1981 (Table 4). The disease was clinically obvious in the 1981 and 1983 collections when 4 of 9 and 8 of 10 reactors, respectively, had severe hoof laminitis. Dr. V. F. Nettles (pers. commun.) viewed the profile of reactors as typical of many southeastern Coastal Plain herds and recommended that when trying to determine a change in disease status that emphasis should be placed on the youngest age class.

There were 4 animals in the 1–2 year age class in the 1988 collection and none tested positive for HD. In 1989, 3 animals were in this age class, all were HD reactors, and 1 1-year-old buck had severe hoof laminitis. Three adult bucks were found dead in fall 1988 in a location of high use by deer but which was well protected from the effects of poaching or malicious shooting. We suspect that these animals died of acute or peracute EHD.

Thomas (1981) suggested that HD could affect seriously the ability of deer to

Table 4. Incidence of bluetongue (BT) and epizootic hemorrhagic disease (EHD) antibodies in serum from deer collected in winter 1981 through 1989 on Hobcaw Barony Plantation, South Carolina.

	Females		Males		
	1–2 years	≥3 years	1–2 years	≥3 years	Total
1981					
N tested	4	6	0	2	12
BT only	0	0		0	0
EHD only	1	3		0	4
BT and EHD	2	1		2	5
Total reactors	3	4		2	9
1983					
N tested	4	4	2	2	12
BT only	0	0	0	0	0
EHD only	2	1	0	0	3
BT and EHD	2	3	0	2	7
Total reactors	4	4	0	2	10
1988					
N tested	3	5	1	0	9
BT only	0	0	0		0
EHD only	0	3	0		3
BT and EHD	0	2			2
Total reactors	0	5	0		5
1989					
N tested	2	6	1	1	10
BT only	0	2	0	0	2
EHD only	0	1	0	0	1
BT and EHD	2	1	1	1	5
Total reactors	2	4	1	1	8
1981–1989					
N tested	13	21	4	5	43
BT only	0	2	0	0	2
EHD only	3	8	0	0	11
BT and EHD	6	7	1	5	19
Total reactors	9	17	1	5	32

acquire and digest forage. We found no difference in conception rates, perirenal fat, or femur marrow fat when reactors and non-reactors were compared. It appeared that in the case of femur marrow fat, the effects of the disease may have been confounded with variation in acorn abundance. We felt that the almost doubling of serum BUN in 1988 compared to 1981 and 1983 may have been in large part attributable to a lack of disease stress in 1988. In contrast, concentrations of serum bilirubin and LDH were at their highest levels when both clinical signs and numbers of HD reactors were most prevalent.

After discovery of a 37% incidence of serological reactors for pseudorabies in feral hogs on Hobcaw in 1980 (G. W. Wood, unpubl. data) and based on a known case of transfer of this disease from wild hogs to cattle (Wood and Barrett 1979), we felt that a check for reactors among the collected deer would be prudent. The check was made only in the 1981 collection and no reactors were found.

Wood et al. (1976) documented an incidence rate of 17.1% for swine brucellosis reactors in the Hobcaw feral hog herd. The incidence level remained about the same level in 1980, but no *Brucella* reactors were found in the 1981 deer collection.

Conclusions

The Hobcaw deer herd density increased rapidly through the late 1970s, underwent a substantial decrease associated with a HD epidemic in the early 1980s, and returned to high levels by fall 1987. While adult doe weights were comparable to those of the deer herd on the nearby Francis Marion National Forest, abnormally low serum levels of BUN and albumin indicated a diet of low nutritional quality. Changes in femur marrow fat reflected changes in fall acorn abundance. In addition, it appeared that greater concentrations of serum BUN and albumin occurred in years of high acorn abundance, and probably resulted from the influence of increased digestible energy intake on rumen microbes.

Conception rates appeared to be consistently high for the Hobcaw herd. Furthermore, conception rates appeared to be insensitive to both HD and nutritional stress. However, it appeared that either breeding dates became progressively later from 1980 to 1988, or fetuses generally declined in weight. Probability of neonate survival would decline with either scenario.

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