# Age, Condition, and Genetic Effects on Incidence of Spike Bucks

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*Abstract:* Data were taken from 3,721 male white-tailed deer (*Odocoileus virginianus*) harvested from the Savannah River Plant in South Carolina for the years 1977 to 1982 to document the incidence of spike bucks relative to habitat differences, harvest methodology, body weight, condition, and genetic variability. Of the 1.5-year-old bucks harvested, 33.1% had spike antlers. The incidence of spike or non-spike antlers was significantly correlated with age ($r = 0.29$) and body weight ($r = 0.37$). Significant differences in the incidence of spike bucks were observed between swamp and upland habitat types. Bucks with higher levels of genetic variability showed greater antler growth in the older age classes. The significant relationship observed between genetic variability and incidence of spiking suggests that breeding structure of the herd could have an important influence on the incidence of spike bucks and environmental parameters may be secondarily involved. Selective spike buck management should be conducted over long periods of time, over large areas, and under conditions where nutritional and demographic constraints are minimal.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 38:23-32

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Hunters are concerned with the quality of their hunting experience and of the game animals sought. Antler size is a prime consideration in determining deer quality. Spike bucks are viewed by hunters as being inferior in quality (Brothers and Ray 1975). Studies addressing the incidence of spike bucks have been undertaken in penned (Williams et al. 1983) and natural populations (Smith et al. 1983) of white-tailed deer. Few long-term studies have documented the incidence of spike bucks relative to herd characteristics or to an individual's condition parameters that can be routinely measured by game personnel or private individuals.

This study was undertaken to document the physical and genetic characteristics associated with spike bucks in a white-tailed deer herd on the U.S. Department of Energy's Savannah River Plant (SRP) in South Carolina. Specifically, the objectives were: 1) to determine the relationship between spike antlers and age, body weight and condition, and genetic variability, 2) to document the year-to-year variability in incidence of spike bucks, 3) to determine if there was any spatial variation in the incidence of spike bucks, and 4) to determine if method of harvest had an effect on the incidence of spike bucks.

This work was supported by contract DE-AC09-76SR00819 between the U.S. Department of Energy and the Institute of Ecology at the University of Georgia.

## Methods

The SRP site (80,972 ha) lies within a 3-county area in west central South Carolina bordering the Savannah River (Urbston 1967). Vegetation consists of predominately planted pine (*Pinus* sp.) on upland areas and swamp and bottomland hardwoods in lower, riparian areas.

The present SRP deer herd has expanded rapidly since acquisition of the property by the Atomic Energy Commission in 1951 (Urbston 1967). The SRP can be divided into swamp and upland hunt compartments based on habitat difference (Manlove et al. 1976) and into still and dog-hunted compartments based on harvest methodology (Scribner et al. 1985).

Data were taken from 3,721 male white-tailed deer harvested on the SRP during fall hunts from 1 October to 31 December during 1977 to 1982. Two to 4 compartments were usually hunted per day. All compartments were not hunted concurrently or in the same order but were hunted at least once each year. Deer were harvested by still hunters or while being driven by dog packs (Scribner et al. 1985). All harvested deer were taken to check stations. Ages were determined by patterns of tooth wear and eruption (Severinghaus 1949) and designated as 1.5, 2.5, or ≥3.5 years old for subsequent analyses. Live body weight and number of antler points were recorded. Kidneys and attached perirenal fat deposits were removed according to the method of Riney (1955) and Finger et al. (1979). The weight of the perirenal fat (g) was divided by the fresh weight of the kidneys (g) and multiplied by 100 to obtain the Kidney Fat Index (KFI). Analyses of KFI were performed with log transformed values (LKFI).

Blood and tissue samples were taken from each animal and subjected to starch gel electrophoresis (Manlove et al. 1975). Starch gel buffers and stains utilized are described in Selander et al. (1971). Nine loci ($\beta$ hemoglobin, esterase-2, aspartate aminotransferase 1 and 2, lactate dehydrogenase-2, malate dehydrogenase-1, phosphoglucomutase-2, sorbitol dehydrogenase, and transferrin) were chosen for analysis. Individual heterozygosity (H) was calculated by dividing the number of loci heterozygous (i.e., with alternate alleles) by the total number of loci (9). Each individual was assigned to a heterozygosity class ($N = 5$) based on the number of loci (0, 1, 2, 3, and 4+) which were heterozygous in that individual.

The effects of different selective removal strategies for spike bucks were modeled using the predictive equation $R = h^2S$. The equation defines the predicted response (R) to directional selection (S) at a given level of heritability ($h^2$) (Falconer 1981). Heritability estimates were arbitrarily assigned as $h^2 = 0.2$ and 0.65 and selective removal rates as −0.1, −0.25, and −0.4. Selection at −0.25 indicates the removal of 25% more spiked than non-spike bucks of the 1.5 age class. Selection cannot exceed −0.5 in that the inferior phenotype cannot be detected in females and, thus, a maximum of 50% spike removal is possible. Statistical analysis was performed using the Statistical Analysis System (SAS Institute Inc. 1982).

## Results

The incidence of bucks with spiked or non-spike antlers was significantly correlated with age ($r = 0.29$, $P < 0.0001$) and body weight ($r = 0.37$, $P < 0.0001$). Spike bucks were most prevalent in the 1.5 age class (33.1%). Of all 2.5-year-old bucks harvested, 5.6% had spike antlers, while 4.8% of bucks ≥3.5 years of age had spike antlers. Body weight appears to be the most important factor associated with point class in SRP deer. Body weight is also significantly correlated with age ($r = 0.71$, $P < 0.0001$). Within an age class, significant differences in body weight between point classes were evident. Mean body weights of spike bucks were significantly lower than that of non-spike bucks at 1.5, 2.5, and ≥3.5 years of age (Table 1). This trend is consistent across harvest groups and between populations harvested from different areas.

No significant correlation was found between point class and body condition (LKFI) or individual heterozygosity. Body condition varied significantly with age in SRP ($F = 10.04$, $df = 3$, $\propto$, $P < 0.0001$); however, no significant difference in fall levels of kidney fat was noted between spike and non-spike bucks of any age class (Table 1). Spike bucks did show a significant trend for higher kidney fat levels per unit of body weight than did non-spike bucks (Sign Test $Z = 2.56$, $P < 0.01$).

Significant differences in the incidence of spike bucks were noted in deer harvested from different regions of the SRP (Fig. 1). There was a significant difference in the incidence of spike bucks in the 1.5 age class harvested from swamp and upland areas ($P < 0.01$). Of 1.5-year-old bucks harvested in the upland areas during the study, 26.6% had spike antlers compared to 35.6% of the bucks in the swamp area. The proportion of spiked bucks in the swamp area remained consistently higher than that in the upland area throughout the

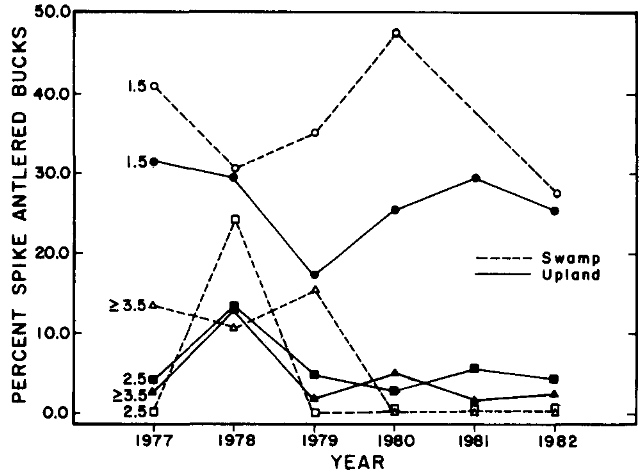

**Figure 1.** Percentage of male white-tailed deer in 3 age classes harvested with spike antlers during 1977 to 1982 from swamp and upland areas of the Savannah River Plant.

study. Significant differences in the incidence of spike bucks were noted among years in the 1.5 ($P = 0.005$), 2.5 ($P < 0.0010$) and ≥3.5 ($P < 0.0001$) age classes in the upland areas (Fig. 1). In the swamp areas, significant yearly differences in the incidence of spikes were noted only for the 2.5 age class ($P < 0.001$).

Significant differences in the incidence of spike bucks were observed between still-hunted and dog-hunted areas of the SRP in the 1.5 age class

**Table 1.** Comparison of mean body weight (kg) and body condition between spike and non-spike bucks in 3 age classes harvested from swamp ($N = 240$) and upland ($N = 1,559$) areas on the Savannah River lant during 1977 to 1982.

| | | AREA | | | |
|---|---|---|---|---|---|
| | | Swamp | | Upland | |
| Age | Point class[a] | Body weight | Kidney fat index (%) | Body weight | Kidney fat index (%) |
| 1.5 | Spike | 47.1 | 29.5 | 47.0 | 29.1 |
| | Non-spike | 50.9 | 28.1 | 52.6 | 28.6 |
| 2.5 | Spike | 56.5 | 27.3 | 57.5 | 31.9 |
| | Non-spike | 65.9 | 31.3 | 66.2 | 29.1 |
| ≥3.5 | Spike | 68.0 | 30.7 | 66.0 | 32.8 |
| | Non-spike | 76.1 | 29.5 | 76.5 | 29.5 |

[a] Body weights differed significantly between spike and non-spike bucks ($F = 515.8$, $df = 1$, $P < 0.0001$) in the 1.5 ($t = 4.39$, $P < 0.025$), 2.5 ($t = 2.97$, $P < 0.05$), and ≥3.5 ($t = 6.96$, $P > 0.01$) years of age. No significant differences in levels of kidney fat were noted between males from two areas ($P > 0.05$) or between spike and non-spike bucks.

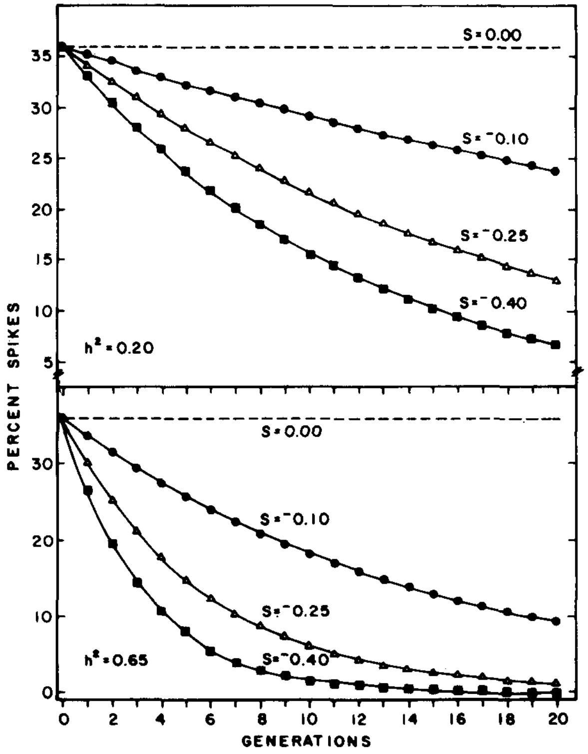

**Figure 2.** Simulation of the changes in the percent occurrence of spike male white-tailed deer in the 1.5 age class for 20 generations on the Savannah River Plant, with 2 different arbitrarily defined heritability coefficients ($h^2$) for the spike antler trait and 3 possible levels of selection against males with spike antlers.

($P < 0.05$). Of the 1.5-year-old bucks harvested in the still-hunted area, 19.2% were spike bucks while 28.0% of the 1.5-year-old males harvested from the dog-hunted area were spike bucks. No significant differences were observed between harvest groups in the 2.5 or ≥3.5 age classes nor were any significant differences observed among years in the incidence of spikes.

Individual heterozygosity was not significantly related to point class in either the spatial analysis or as affected by hunting methodology. However, when individuals were assigned to heterozygosity classes of 0–4+ loci, significant variation in the incidence of spike bucks was noted between heterozygosity classes for the 2.5 ($P = 0.005$) and the ≥3.5 age class ($P = 0.05$) (Table 2). A significantly greater proportion of spike bucks was observed in the lower heterozygosity classes than in higher heterozygosity classes.

Modelling revealed that selective removal of spike bucks can have a significant impact on the incidence of spike bucks if the selective pressure is maintained over an extended period of time (Fig. 2). A higher heritability for the trait (i.e., $h^2 = 0.65$) will result in a more rapid loss of spikes in the population under the same selective pressure than if the spike characteristic has a lower heritability. In addition, heavy selection (i.e., hunting pressure) against

**Table 2.** Percentage of spike-antlered white-tailed deer heterozygous at 0, 1, 2, 3, or 4 or more loci at 1.5, 2.5, and ⩾3.5 years of age. Deer were collected during fall hunts on the Savannah River Plant from 1977 to 1982.

| Age | | Number of Heterozygous Loci[a] | | | | | Total |
|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | ≥4 | |
| 1.5 | % | 40.8 | 31.8 | 34.6 | 26.6 | 36.9 | 33.1 |
| | *N*[b] | 93 | 236 | 266 | 184 | 103 | 882 |
| 2.5 | % | 15.9 | 7.7 | 8.0 | 2.4 | 3.4 | 7.1 |
| | *N* | 88 | 108 | 224 | 170 | 88 | 738 |
| ⩾3.5 | % | 9.8 | 6.6 | 3.5 | 0.0 | 2.2 | 4.0 |
| | *N* | 41 | 122 | 144 | 97 | 44 | 448 |

[a] Incidence of spike bucks at the 5 heterozygous classes was significantly different for the 2.5 age class ($\chi^2 = 18.8$, 4 df, $P < 0.005$) and the $\geq 3.5$ age class ($\chi^2 = 10.08$, 4 df, $P < 0.05$). No significant differences were noted in the 1.5 age class ($\chi^2 = 7.04$, 4 df, $P > 0.05$).

[b] *N* designates the total sample size for an age-heterozygosity class.

spike bucks in an age class will decrease the incidence of spike bucks at a rapid rate.

## Discussion

Differences in age-specific antler characteristics over the years of this study could be an artifact of previous qualitative demographic and physical differences between deer from the different areas. Previous studies of deer on the SRP have documented differences in demographic (Dapson et al. 1979), reproductive (Urbston 1976), body condition (Urbston 1976, Johns et al. 1984), and genetic characteristics (Ramsey et al. 1979) between swamp and upland areas of the SRP. Lower fawn production, survivorship, and condition parameters observed in the swamp areas were thought to be the result of density-dependent factors combined with qualitative habitat differences (Urbston 1976).

Increasing levels of genetic variability (i.e., heterozygosity) appear to be related to point class in older age classes (Table 2). Of the loci surveyed, no single locus affect can be used as an explanation of differential antler development (Smith et al. 1983). However, pen studies of the antler development by different known lineages of bucks with inferior and superior lines suggest some level of inheritance (Harmel 1983). Heterozygosity is only 1 measure of an individuals' genetic make-up. The significant relationship observed between the incidence of spike bucks and increasing heterozygosity in 2.5- and ⩾3.5-year-old bucks would seem to suggest some genetic component affecting the expression of spike antlers. Lower antler quality for bucks of the lower heterozygosity classes could indicate that antler quality may be in part, effected by inbreeding. Levels of inbreeding can be altered by effective population size (Wright 1969). Effective population size is related to absolute numbers of animals and past demographic characteristics of the herd. Population sex ratio and age structure are also of potential influence because of the social breeding-dominance hierarchy noted in male white-tailed deer (Hirth 1977). A highly skewed sex ratio in favor of females should accelerate inbreeding because a smaller number of males could breed most of the available females. A harvest strategy favoring 1 sex (i.e., does) and/or the over-harvest and resulting younger mean ages of bucks will also influence the breeding structure and levels of inbreeding within the population (Ryman et al. 1981). A decrease in male mean age could result in a greater proportion of younger, potentially smaller, and less desirable bucks participating in the breeding. A selective spike harvest conducted prior to the rut could diminish the possibility of less desirable bucks participating in the breeding.

Increased harvest intensity on the SRP has resulted in a decrease in mean age and correspondingly a decrease in body size and mean number of antler points (Smith et al. 1983). The temporal variation in age structure is further reflected relative to method of harvest (still vs. dog; Scribner et al. 1985). Using dogs to harvest deer also results in greater dispersion of deer (Sweeney et al. 1971) during the rut and thus affects breeding structure. This is reflected in significant year-to-year differences in gene frequency in the fawn age class in the dog areas (Scribner et al. 1985). Deer densities in both still- and dog-hunted areas are well below carrying capacity. Both areas are located in similar upland habitats. With young herd age structure (mean herd age during 1977–82 of 1.7 years; Scribner et al. 1985) and documented temporal genetic variability relative to harvest methodology, the greater incidence of spiking in the dog-hunted areas could also be an indication of variability in breeding structure.

Is selection against spike bucks likely to result in an overall improvement in a herd? The answer depends upon the degree to which the phenotype "spike" is caused by environmental or genetic factors. If environmental causes are all pervasive, then selection will have no effect on the incidence of this character. The lack of correlation between LKFI and the incidence of spike bucks does not support a hypothesis stressing the importance of habitat effects. The relationship between the incidence of $\geqslant$2-year-old spike bucks and heterozygosity indicates the potential importance of genetics in explaining this phenomenon. The non-significant relationship between spiking and heterozygosity in the 1.5 age class could indicate that the relationship may be masked by externally induced spikes and may not be consistently apparent until the phenotypic potential is more fully developed in the older age classes. Spike 1.5-year-old bucks could include genetically inferior animals as well as younger or nutritionally stressed, but genetically superior animals within the 1.5 class.

Can selection against spike bucks be effective in changing the genetic character of the herd? If the inbreeding hypothesis is correct, selection against spikes would be the same as selecting for mating behavior that results in outbreeding, or against the expression of the inbreeding depression. Any improvement in the genetic composition of the herd could be quite slow because it would probably require the elimination of recessive alleles from the population, and this requires a high intensity of selection against them and a large number of generations.

Body weight and antler development are quantitative traits theorized to be influenced by polygenic inheritance. Such traits normally have moderate heritability (i.e., body weight in cattle $h^2 = 65\%$) (Falconer 1981). With moderate $h^2$ and high intensity selection against spike bucks, progress in improving the herd could be dramatic (Fig. 2). Selection must be clear-cut because every animal killed that is not a spike buck makes it more difficult to generate a high selection against spikes. In addition, since spike antlers are known to occur more frequently in younger animals, every inferior (i.e., spike at 1.5 years) buck that reaches an older age and fails to show the spike antlers further reduces the opportunity for selection. The progress of selection against spike bucks will be slowed considerably because females carrying the spike antler gene(s) in a homozygous or heterozygous form cannot be identified and removed, but must be selected against indirectly through her male offspring. Dispersal of inferior deer into an area can also negate the positive effects of selective harvest pressure against spike bucks. Selection should be uniform throughout a large area to diminish the effect of inferior males coming into the area of selection after the harvest and breeding. Herd improvement would thus be hindered when selective harvest is conducted on small tracts of land. Depending upon the local conditions, progress in reducing spikes in a herd could vary considerably. Considering the potential confounding influences of habitat and condition parameters, selection against spike bucks in a nutritionally stressed population could result in the elimination of individuals thought to be genetically inferior but are not. Therefore, selective spike buck management should be conducted where habitat and density conditions are optimal.

## Literature Cited

Brothers, A. and M. E. Ray, Jr. 1975. Producing quality white-tails. Caesar Kleberg Wildl. Res. Inst. Kingsville, Texas. 247pp.

Dapson, R. W., P. R. Ramsey, M. H. Smith, and D. F. Urbston. 1979. Demographic differences in contiguous populations of white-tailed deer. J. Wildl. Manage. 43:889–898.

Falconer, D. S. 1981. Introduction to quantitative genetics. Longman Inc., New York. 340pp.

Finger, S. E., I. L. Brisbin, Jr., M. H. Smith, and D. F. Urbston. 1979. Kidney fat as a predictor of body condition in white-tailed deer. J. Wildl. Manage. 45: 964–968.

Harmel, D. E. 1983. Effects of genetics on antler quality and body size in white-tailed deer. Pages 339–348 *in* R. D. Brown, ed. Antler development in Cervidae. Caesar Kleberg Wildl. Res. Inst. Kingsville, Texas.

Hirth, D. H. 1977. Social behavior of white-tailed deer in relation to habitat. Wildl. Monogr. 53. Supplement.

Johns, P. E., M. H. Smith, and R. K. Chesser. 1984. Annual cycles of the kidney fat index in a southeastern white-tailed deer herd. J. Wildl. Manage. 48: 969–973.

Manlove, M. N., J. C. Avise, H. O. Hillestad, P. R. Ramsey, M. H. Smith, and D. O. Straney. 1975. Starch gel electrophoresis for the study of population genetics in white-tailed deer. Proc. Annu. Conf. Southeast Assoc. Fish and Wildl. Agencies. 29:392–403.

Manlove, M. N., M. H. Smith, H. O. Hillestad, S. E. Fuller, P. E. Johns, and D. O. Straney. 1976. Genetic subdivision in a herd of white-tailed deer as demonstrated by spatial shifts in gene frequencies. Proc. Annu. Conf. Southeast Assoc. Fish and Wildl. Agencies. 30:487–492.

Ramsey, P. R., J. C. Avise, M. H. Smith, and D. F. Urbston. 1979. Biochemical variation and genetic heterogeneity in South Carolina deer populations. J. Wildl. Manage. 43:136–142.

Riney, T. 1955. Evaluating condition of free-ranging red deer (*Cervus elaphus*), with special reference to New Zealand. New Zealand J. Sci. Tech. B 36: 429–463.

Ryman, N., R. Baccus, C. Reuterwell, and M. H. Smith. 1981. Effective population size and loss of genetic variability in moose and white-tailed deer under different hunting regimes. Oikos. 36:257–266.

SAS Institute Inc. 1982. SAS Users Guide: Statistics, 1982 edition. Cary, N.C., SAS Institute Inc. 584pp.

Scribner, K. T., M. C. Wooten, M. H. Smith, and P. E. Johns. 1985. Demographic and genetic characteristics of white-tailed deer populations subjected to different harvest methods. Pages 197–213 *in* S. L. Beasom, ed. Symposium on game harvest management. Caesar Kleberg Wildl. Res. Inst., Kingsville, Texas.

Selander, R. K., M. H. Smith, S. Y. Yang, W. E. Johnson, and J. B. Gentry. 1971. Biochemical polymorphism and systematics in the genus *Peromyscus*. I. Variation in the old-field mouse (*Peromyscus polionotus*). Studies in Genetics, 6. Univ. Texas Publ. 7103:49–90.

Severinghaus, C. W. 1949. Tooth development and wear as criteria for age in white-tailed deer. J. Wildl. Manage. 13:195–216.

Smith, M. H., R. K. Chesser, E. G. Cothran, and P. E. Johns. 1983. Genetic variability and antler growth in a natural population of white-tailed deer. Pages 365–388 *in* R. D. Brown, ed. Antler development in Cervidae. Caesar Kleberg Wildl. Res. Inst., Kingsville, Texas.

Sweeney, J. R., R. L. Marchinton, and J. M. Sweeney. 1971. Responses of radio-monitored white-tailed deer chased by hunting dogs. J. Wildl. Manage. 35: 707–716.

Urbston, D. F. 1967. Herd dynamics of a pioneer-like deer population. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies. 21:42–50.

Urbston, D. F. 1976. Descriptive aspects of two fawn populations as delineated by reproductive differences. Ph.D. Diss., Va. Polytechnic Inst. and State Univ., Blacksburg. 102pp.

Williams, J. D., D. E. Harmel, W. E. Armstrong, and S. E. Wardroup. 1983. Antler development in the white-tailed deer. Page 468 *in* R. D. Brown, ed. Antler development in Cervidae. Caesar Kleberg Wildl. Res. Inst., Kingsville, Texas.

Wright, S. E. 1969. The theory of gene frequencies. Vol. II. Evolution and the genetics of populations. Univ. Chicago Press. Chicago, Ill. 511pp.