COMPARISON OF ANTLER CHARACTERISTICS AND BODY WEIGHTS OF SPIKE- AND FORK-ANTLERED YEARLING WHITE-TAILED DEER AT 2.5 YEARS OF AGE

THESIS

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Introduction

Due to its popularity, the white-tailed deer (*Odocoileus virginianus*) is an important wildlife and economic resource for many states in the United States, including Texas. In 1975, an estimated $8.22 billion was generated from activities associated with white-tailed deer in the United States (Langenau et al., 1984). Each year, hunters spend money on food, lodging, hunting supplies, and licenses. Also, hunters create jobs that may not otherwise be available during the hunting season. In Texas however, a significant percentage of the economic capital is garnered by landowners and managers in money paid for hunting leases and packaged hunts. Those who manage for production of high quality white-tailed bucks will increase their economic revenue. Therefore, with the increase in the popularity of trophy white-tailed deer hunting, there has also been an increase in the management of white-tailed deer herds.

Many landowners and wildlife managers have implemented management practices aimed at improving habitat in an effort to increase body and antler size in their deer herds. These practices vary from simple management strategies to intense management programs. However, one management issue remains highly controversial regardless of the management intensity. This issue is the management of spike-antlered bucks (Brothers et al., 1995; Armstrong et al., 1994; Harmel et al., 1989; Cox, 1982; Baxter et al., 1981). Managers who resist harvesting spike-antlered bucks assert that these deer are not inferior (poor antler characteristics and body weight) in comparison to other bucks when compared in older age classes and must be protected to ensure adequate numbers of bucks in future harvests. It is also believed that given time, spike-antlered bucks will "catch up" to their fork-antlered cohorts with respect to body size and antler quality. The proponents of harvesting spike-antlered bucks argue that these deer are inferior to other bucks and should be removed from the herd (Ott et al., 1998; Harmel et al., 1989).

In order to resolve the spike controversy, factors affecting antler growth must be examined. White-tailed deer antler size and conformation, as well as body weight, are affected by three main variables: age, nutrition, and genetics (Jacobson, 1995; Marchinton et al., 1995; Armstrong et al., 1994; Harmel et al., 1989; Scribner et al., 1989; Verme and Ullrey, 1984; Harmel, 1983; Williams et al., 1983; Cox, 1982; Ullrey, 1982; Baxter et al., 1981). Williams et al. (1994) found body weight, antler points, main beam length, spread, and antler weight were intermediate to highly heritable traits in white-tailed deer.

White-tailed deer antlers are deciduous formations made of bone. During March or April, changes in photoperiod causes increased levels of testosterone in white-tailed bucks (Schultz and Johnson, 1992; Forand et al., 1985; Sauer, 1984; Verme and Ullrey, 1984). Testosterone levels affect the formation of antlers (Miller et al., 1985). Increases in testosterone levels cause antler growth to begin at structures called pedicels, which are located on the frontal bones of the skull (Jacobson, 1995; Ozoga, 1988). While antlers are growing, they are covered with hairy skin containing nerves and blood vessels. This hairy skin is called velvet, and remains on the antlers until growth is completed. Once growth is completed in late summer or early fall, the velvet falls off or is "rubbed" off. By January, with a decreased photoperiod, testosterone levels decrease to a level at which the antlers are cast, or fall off (Sauer, 1984). This cycle of antler growth will repeat itself each year of the buck's life span.

Antler growth is a curvilinear function of age (Scribner et al., 1989). Most white-tailed bucks grow their first set of antlers at 1.5 years of age. However, some fawns (≤ 9 months old) may form small buttons which protrude from the skin, allowing them to be considered true antlers (Ozoga, 1988). Antler size and configuration generally increases each year until the buck reaches 4.5 to 5.5 years of age (Jacobson, 1995; Sauer, 1984). At this point, antler size stabilizes, or may begin to decrease with each successive year.

Schultz and Johnson (1995) found that bucks with a greater body mass at birth added more body mass with age and had greater body mass at older ages. They also stated that body mass may be an index of physiological status or condition.

Nutrition is an important variable in antler development (Asleson et al., 1996; Armstrong, 1994; Grassman and Hellgren, 1993; Harmel et al., 1989; Verme and Ullrey, 1984; Cox, 1982; Baxter et al., 1981). Body weight and antler characteristics respond directly to quality of diet. Without adequate nutrition, white-tailed bucks will not reach their genetic potential for antler production and weight gain (Armstrong, 1991). A diet consisting of at least 16% crude protein is considered an optimal diet for maximum antler and body growth. Antler and body growth are diminished on a diet of less than 13% crude protein (Baxter et al.,1981). Adequate amounts of phosphorous (a limited mineral) and calcium are important in the production of antlers and body growth (Weeks, 1995; Grasman and Hellgren, 1993). In white-tailed deer, nutrients are used for body growth and maintenance before they are used for antler formation (Scribner et al., 1989). Therefore, a diet of 13-18% crude protein, with sufficient amounts of calcium and phosphorous, is considered adequate for antler development and body growth. Increases in population densities can cause decreases in diet quantity and quality, leading to delays and/or decreases in antler production and body weights (Cook, 1984; Sauer, 1984; Verme and Ullrey, 1984). Also, nutrient intake can be affected by digestibility of the forage available in that particular habitat (Gray and Servello, 1995).

Cox (1982) opined that although genetics may be important in antler growth and body weight, most spike-antlered yearlings were a result of inadequate nutrition in their diets. Date of birth is another factor that causes spike-antlered yearlings (Schultz and Johnson, 1992). Deer born late in the fawning season have less time to feed on forage before nutritional values decrease due to winter dormancy (Jacobson, 1995). Bred yearling does may lack adequate amounts of nutritious milk for fawn bucks to develop at the same rate as their cohorts born to mature does. Does which produce twins or triplets may have limited milk to provide adequate nutrition to feed all her fawns (Brothers et al., 1995).

Hendrix (1998) compared antler characteristics and body weights of spike-antlered and fork-antlered deer as yearlings using the Boone and Crockett scoring system. He found significant differences in antler characteristics and body weights between spike-antlered yearlings and fork-antlered yearlings, with fork-antlered yearlings having greater body weights and greater antler measurements than spike-antlered yearlings. Hendrix (1998) also found that date of birth alone, could not account for the presence of spike-antlered deer. Roberts (1996) and Ott et al. (1997) compared spike-antlered and fork-antlered yearlings at maturity (4.5 years of age) using the Boone and Crockett scoring system, and found that fork-antlered yearlings at 4.5 years of age had significantly larger antler measurements and body weights than the spike-antlered yearlings at 4.5 years of age.

The purpose of this study was to compare antler size and configuration using the Boone and Crockett scoring system and body weight of 2.5 year old bucks that were spike-antlered as yearlings and fork-antlered as yearlings. I sought to determine if there was a difference in body weight and antler growth between spike-antlered and fork-antlered yearlings under controlled optimal conditions at 2.5 years of age. The null hypothesis was no difference in body weight and antler size in 2.5 year old bucks that were spike-antlered or fork-antlered as yearlings. The alternative hypothesis was that there is a difference in body weight and antler size between 2.5 year old bucks that were spike-antlered as yearlings and 2.5 year old bucks that were fork-antlered as yearlings.

To remain consistent with Hendrix (1998), Ott et al. (1997), and Roberts (1996), I also sought to determine whether a two-class system (spike-antlered as yearlings or fork-antlered as yearlings) of classifying white-tailed deer at 2.5 years of age was an over simplification of antler development. Therefore, I classified the 2.5 year old bucks into 3 groups: spike-antlered as yearlings, 3-5 points as yearlings, and $\geq$ 6 points as yearlings. The null hypothesis was no difference in body weight and antler size in spike-antlered yearlings at 2.5 years of age, 3-5 points as yearlings at 2.5 years of age, or $\geq$ 6 points as yearlings at 2.5 years of age. The alternate hypothesis was a difference in body weight and antler size between the three groups of bucks at 2.5 years of age.

Finally, I sought to determine if there was a significant relationship between gross Boone and Crockett scores of 2.5 year old bucks and live body weights at both 1.5 years of age and 2.5 years of age. Relationships between Julian birthdates and both live body weights and gross Boone and Crockett scores at 2.5 years of age were also examined. These relationships were further examined to determine if they differed between spike-antlered and fork-antlered yearling bucks at 2.5 years of age.

Study Herd and Methods

Antler measurements used in this study were obtained from antlers produced by bucks in the Kerr Wildlife Management Area's (KWMA) pedigreed white-tailed deer herd. The KWMA, owned and operated by the Texas Parks and Wildlife Department, established the pedigreed white-tailed deer herd in 1973 to conduct studies on the role of nutrition and genetics on the variation in body and antler traits in white-tailed deer. The composition of the breeding herd was native white-tailed deer collected from throughout the state. The offspring of the original breeding herd has been maintained as a closed-pedigreed herd since 1974. Random matings between spike-antlered as yearling and fork-antlered as yearling bucks with does have been used in the breeding process. In late spring and early summer, data collected for each new fawn included date of birth, weight, and sex. Each fawn was identified by an ear tag with an identification number.

All bucks used in this study were fed a diet containing 16%+ crude protein. Calcium, phosphorous, vitamins, and trace elements were also included in the diet. The feed consisted of a pelleted ration that was fed ad libitum to all deer.

All bucks were captured in early fall for antler removal. For each buck, live body weight was recorded, the inside antler spread was measured, and the antlers were removed approximately 1 cm above the pedicel. The identification number of the buck, as well as the date, were recorded on each set of antlers.

Antlers from 252 male deer 2.5 years old were examined. All deer were born between 1973 and 1991, and only bucks with complete antler sets were used in the study. Bucks with no data on greatest inside spread, weight, or birthdate were eliminated from the analysis of those particular categories. Bucks were classified as spike-antlered or fork-antlered according to the number of tines ≥ 2.54 cm (≥ 1 in) in length at 1.5 years of age. To compare data for 2.5 year old bucks with 1.5 year old bucks (Hendrix,1998), all antlers were measured and scored using the Boone and Crockett system (B&C) to obtain a gross B&C score (GBC).

The Boone and Crockett scoring system was used because it is the most commonly used measuring system to quantify antler characteristics (Hendrix, 1998). This method of scoring is based on a system in which one inch of antler growth equals one point (Boone and Crockett, 1981). Measurements of the B&C scoring system (Figure 1, p. 43) include: (1) greatest inside spread between main beams (SP), (2) length of left and right main beams (LMB & RMB), (3) length of all typical tines (G_1-G_n), (4) four circumference measurements for both left and right antlers (H_1-H_4), and (5) length of all abnormal, or atypical, tines (AB_1-AB_n). A Gross B&C score was obtained using the following formula: $GBC = SP + \Sigma MB + \Sigma G_n + \Sigma H_n + \Sigma AB_n$; where SP = greatest inside distance between the two antlers; ΣMB = combined lengths of both right and left main beams; ΣG_n = total length of all typical tines on both right and left antlers; ΣH_n = total circumference of the four measurements for both right and left main beams; and ΣAB_n = total length of all abnormal, or atypical, tines. All measurements were taken using ¼" flexible steel tape and cable, and were recorded to the nearest mm. Measurements were later converted to inches to calculate GBC scores. Tests of normality and tests of equality of variances showed that no transformations were required for any dependent variables analyzed herein (Hendrix, 1998; Ott et al., 1997).

The first circumference measurement (H_1) was taken at the smallest point between the pedicel and browtine (G_1), the H_2 measurement between the browtine and second tine (G_2), etc. If there was not a browtine present, the first and second circumference measurements (H_1, H_2) were taken at the smallest point between the pedicel and the second typical point (G_2). If there was a browtine present, and no G_2, the first and second circumference measurements (H_1, H_2) were made at the smallest point between the pedicle and the browtine, and the third and fourth circumference measurements (H_3, H_4) were made at the midpoint between the browtine and the tip of the main beam. Circumference measurements (H_1 - H_4) for spikes were taken at the midpoint of the main beam since no typical or abnormal tines were present.

STATISTICAL ANALYSIS

GBC scores, GBC components (SP, ΣGn, etc.) and live body weights of 2.5 year old bucks that were spike-antlered as yearlings (SAY) and fork-antlered as yearlings (FAY) were compared using t-tests. Relationships between $GBC_{2.5\ yrs}$ and $Wt_{1.5\ yrs}$, $GBC_{2.5\ yrs}$ and $Wt_{2.5\ yrs}$, Julian birthdate and $Wt_{2.5\ yrs}$, and Julian birthdate and $GBC_{2.5\ yrs}$ were compared using a mixed model analysis of variance (ANOVA) and linear regression. Pearson correlation coefficients were calculated for weight, GBC, and GBC components between the SAY bucks and FAY bucks at 2.5 years of age. In addition, the percent contribution of GBC components to the GBC score were computed and examined between SAY and FAY bucks.

After comparing bucks as SAY and FAY groups, a second analysis was performed by placing the 2.5 year old bucks into 3 groups: spike-antlered as yearlings (Group 1), 3-5 points as yearlings (Group 2), and $\geq$ 6 points as yearlings (Group 3). GBC scores, GBC components, and live body weights were compared among the 3 groups using ANOVA followed by means comparison (Ryan-Einot-Gabriel-Welsch multiple *F* test). Pearson correlation coefficients were calculated for weight, GBC, and GBC components for the three groups of bucks. Finally, percent contribution of GBC components to GBC score were computed and compared between the 3 classes.

Results

GROSS B&C SCORES

Spike-antlered yearling bucks (SAY) had significantly lower GBC scores than those of fork-antlered yearling (FAY) bucks at 2.5 years of age. The mean GBC score for SAY bucks at 2.5 years of age was 63.8 (SE = 2.21; N = 63) points (inches), while the mean GBC score for 2.5 year old FAY bucks was 92.5 (SE = 1.24; N = 183; Table 1, p. 36). There was a significant difference (28.7 points) between the mean GBC score of SAY bucks and FAY bucks at 2.5 years of age ($t = 11.61$, $df = 244$; $P < 0.0001$). There was a 14.4 point difference in the GBC score of the best SAY buck (118.2) and the best FAY buck (132.6). There was a 36 point difference in the GBC score of the lowest scoring SAY buck (14.8) and the lowest scoring FAY buck (50.8). A total of 23 (37%) SAY bucks had GBC scores $\geq$ 70 points, while 166 (90%) FAY bucks had scores $\geq$ 70 points (Figure 2, p. 44).

LIVE BODY WEIGHTS

Spike-antlered yearling (SAY) bucks weighed significantly less than fork-antlered yearling (FAY) bucks at 2.5 years of age. The mean live body weights were 53.8 kg (SE = 0.88; N = 56) for SAY bucks and 64.1 kg (SE = 0.59; N = 182) for FAY bucks (Table 1, p. 36). The mean live body weight for the SAY bucks was significantly lower than the mean live body weight for the FAY bucks ($t = 9.77$, $df = 108$; $P < 0.0001$). There was an 18.2 kg difference between the heaviest SAY buck (66.2 kg) and the heaviest FAY buck (84.4 kg). A total of 13 (24%) SAY bucks weighed more than 60 kg, while 122 (56%) FAY bucks weighed more than 60 kg (Figure 3, p. 45).

COMPARISON OF GBC COMPONENTS

At 2.5 years of age, spike-antlered yearling (SAY) bucks produced lower scores than did fork-antlered yearling (FAY) bucks for all GBC components. The mean spread (SP) measurement for SAY bucks was 11.2 (SE = 0.32; N = 63) and 13.9 (SE = 0.16; N = 183) for FAY bucks (Table 1, p. 36). There was a significant difference between the mean spread (SP) measurements between SAY bucks and FAY bucks ($t = 7.23$, $df = 95$; $P < 0.0001$). The mean sum of main beam measurement (ΣMB) for SAY bucks was 23.9 (SE = 0.79; N = 65) and 31.1 (SE = 0.32; N = 187) for FAY bucks (Table 1, p. 36). Comparison of the mean sum of main beam (ΣMB) measurements indicated significant differences between SAY bucks and FAY bucks ($t = 8.47$, $df = 85$; $P < 0.0001$). Mean ΣG_n (sum of all tine measurements) scores were 10.8 (SE = 0.99; N = 65) for SAY bucks and 25.3 (SE = 0.66; N = 187) for FAY bucks (Table 1, p. 36). FAY bucks had a significantly higher mean ΣG_n scores than did SAY bucks at 2.5 years of age ($t = 12.19$, $df = 125$; $P < 0.0001$). The mean ΣH_n (sum of all circumference measurements) were 17.4 (SE = 0.35 N = 65) for SAY bucks and 21.5 (SE = 0.19; N = 187) for FAY bucks (Table 1, p. 36). At 2.5 years of age, FAY bucks had a higher mean ΣH_n measurement than did SAY bucks ($t = 10.33$, $df = 250$; $P < 0.0001$). The mean ΣAB_n (sum of all abnormal tine length measurements) were 0.04 (SE = 0.03; N = 65) for SAY bucks and 0.53 (SE = 0.13; N = 187) for FAY bucks (Table 1, p. 36). Although this GBC component contributed little to the GBC scores of 2.5 year old bucks, there was a significant difference between the mean sum of abnormal tine length (ΣAB_n) measurements between SAY bucks and FAY bucks ($t = 3.48$, $df = 204$; $P < 0.0006$).

CONTRIBUTION OF B&C COMPONENTS TO GBC SCORES

Length measurements (ΣMB, ΣG_n) contributed the most to the overall GBC scores of fork-antlered yearling (FAY) bucks at 2.5 years of age, whereas circumference measurements contributed the most to overall GBC scores of spike-antlered yearling (SAY) bucks at 2.5 years of age. Spread accounted for 17.6% of the GBC score for SAY bucks, while it accounted for 15% of the GBC score for FAY bucks. Main beam lengths accounted for 37.9% of the GBC score for SAY bucks, while accounting for 33.7% of the GBC score for FAY bucks. The ΣG_n measurements for SAY bucks accounted for only 17.2% of the GBC score, while the ΣG_n measurements accounted for 27.6% of FAY bucks' GBC scores. The ΣH_n measurements accounted for 27.4% of SAY bucks GBC scores, while accounting for only 23.3% of the FAY bucks' GBC score. The sum of abnormal points for SAY bucks and FAY bucks (0.04% and 0.5%, respectively) were minimal components in the GBC score in both groups (Figure 4, p. 46).

INCREASE OF GBC SCORES FROM 1.5 TO 2.5 YEARS OF AGE

Analysis of the mean increase in GBC scores (ΔGBC) from 1.5 to 2.5 years of age showed no differences between ΔGBC for fork-antlered and ΔGBC for spike-antlered yearling bucks at 2.5 years of age. The mean increase in GBC scores from 1.5 to 2.5 years of age for FAY bucks was 34.5 (SE = 0.91; N =171) points, while the mean increase in GBC scores for SAY bucks from 1.5 to 2.5 years of age was 34.0 (SE = 1.91; N = 47; Table 1, p. 36). There was no significant difference in the mean change in the GBC score from 1.5 to 2.5 years of age between the SAY and FAY bucks ($t = 0.23$, $df = 68$; $P < 0.82$).

INCREASE IN WEIGHT FROM 1.5 TO 2.5 YEARS OF AGE

Mean increase in weight from 1.5 to 2.5 years of age for FAY bucks was 11.89 (SE = 0.35; N = 171) kg while the mean change in weight from 1.5 to 2.5 years of age for SAY bucks was 10.29 (SE = 0.67; N = 52) kg (Table 1, p. 36). Analysis of the mean increase in live body weights from 1.5 to 2.5 years of age between SAY bucks and FAY bucks shows there was a significant difference in the mean weight change from 1.5 to 2.5 years of age between the SAY bucks and the FAY bucks at 2.5 years of age ($t = 2.19$, $df = 221$; $P < 0.029$).

TOTAL POINTS (TYPICAL AND ATYPICAL)

Comparison of the total number of points for bucks at 2.5 years of age shows that fork-antlered yearling (FAY) bucks had more total points than spike-antlered yearling (SAY) bucks. The mean total number of points for SAY bucks was 5.26 (SE = 0.24; N = 65), while the mean total points for FAY bucks was 7.55 (SE = 0.10; N = 187) points (Table 1, p. 36). SAY bucks had a significantly lower mean total number of points than FAY bucks at 2.5 years of age ($t = 8.64$, $df = 88$; $P < 0.0001$). Of the 65 SAY bucks, only 11 (17%) had ≥ 8 points, while 115 (62%) of 187 FAY bucks had ≥ 8 points. There was a four point difference between the best SAY buck (9 points) and the best FAY buck (13 points). No FAY bucks had ≤ 3 points, while 11 (17%) SAY bucks had ≤ 3 points (Figure 5, p. 47).

JULIAN BIRTHDATES

To determine if FAY bucks and SAY bucks were born at different time periods, Julian birthdates of the two groups were compared by means of a t-test. The mean Julian birthdate for SAY bucks was day 182 (SE = 3.46; N = 56), while the mean Julian birthdate for FAY bucks was day 163 (SE = 1.57; N = 184; Table 1, p. 36). FAY bucks were born significantly earlier than SAY bucks ($t = 4.91$, $df = 78$; $P < 0.0001$).

CORRELATIONS AMONG WEIGHT, GBC SCORES, AND GBC COMPONENTS

Pearson correlation coefficients were calculated to determine examine the degree of correlation between weight at 1.5 and 2.5 years of age, GBC at 1.5 and 2.5 years of age, GBC components, total number of points, and Julian birthdate. When all 2.5 year old bucks were combined, there was a highly significant correlation between weight at 1.5 years of age and weight at 2.5 years of age (0.85). The GBC scores for 2.5 year old bucks were highly correlated with ΣMB (0.93), ΣH_n (0.90), and ΣG_n (0.96). GBC components that were highly correlated include ΣMB and ΣH_n (0.79), ΣMB and ΣG_n (0.82), ΣMB and SP (0.77), ΣH_n and ΣG_n (0.84), and number of abnormal points and length of abnormal points (0.81; Table 3, p. 38).

For the SAY bucks, weights at 1.5 and 2.5 were highly correlated (0.70). The GBC scores for SAY bucks at 2.5 years of age were highly correlated with SMB (0.95), ΣH_n (0.88), ΣG_n (0.92), and SP (0.75). GBC components that were highly correlated included ΣMB and ΣH_n (0.79), ΣMB and ΣG_n (0.79), ΣMB and SP (0.80), ΣH_n and ΣG_n

(0.78), and the number of abnormal points and length of abnormal points (0.98; Table 4, p. 39).

For the FAY bucks at 2.5 years of age, weights at 1.5 and 2.5 years were highly correlated (0.82). The GBC scores for FAY bucks at 2.5 years of age were highly correlated with ΣMB (0.88), ΣH_n (0.85), ΣG_n (0.95), and SP (0.65). GBC components that were highly correlated included ΣMB and ΣH_n (0.68), ΣMB and ΣG_n (0.74), ΣMB and SP (0.65), ΣG_n and ΣH_n (0.77), and the number of abnormal points and length of abnormal points (0.81; Table 5, p. 40).

COMPARISON OF GBC SCORES AMONG SPIKE- ANTLERED, 3-5 POINT, AND $\geq$ 6 POINT YEARLINGS AT 2.5 YEARS OF AGE

To determine if the SAY buck and FAY buck classification was an over simplification, the two classes were broken into three groups, based on number the number of points $\geq$ 2.54 cm at 1.5 years of age. At 2.5 years of age, bucks that had $\geq$ 6 points as yearlings has significantly higher GBC scores than bucks that had 3-5 points as yearlings, while bucks that had 3-5 points as yearlings had higher GBC scores than buck that were spike-antlered as yearlings. The mean GBC score of 2.5 year old bucks with $\geq$ 6 points as yearlings (Group 3) was 99.59 (SE = 1.45; N =108) points at 2.5 years of age (Table 2, p. 37). Bucks with 3 –5 points as yearlings (Group 2) had a mean GBC score of 82.38 (SE = 1.56; N = 75) at 2.5 years of age, while bucks that were spike-antlered as yearlings (Group 1) had a mean GBC score of 63.80 (SE = 2.21; N = 63) at 2.5 years of age. A Ryan-Einot-Gabriel-Welsch multiple *F* test showed means of the 3 groups were all significantly different ($P < 0.0001$). Of the Group 3 bucks, 97

(90%) scored ≥ 80 GBC points, while 44 (59%) Group 2 bucks and only 9 (15%) Group 1 bucks scored ≥ 80 GBC points. No Group 3 bucks scored ≤ 60 GBC points, while 31 (41%) group 2 bucks and 54 (85%) Group 1 bucks scored ≤ 60 GBC points (Figure 6, p. 48).

COMPARISON OF LIVE BODY WEIGHT AMONG SPIKE- ANTLERED, 3-5 POINT, AND ≥ 6 POINT YEARLINGS AT 2.5 YEARS OF AGE

At 2.5 years of age, the mean live body weight of Group 3 bucks were higher than the mean live body weight of Group 2 bucks and Group 1 bucks. The mean live body weight for Group 3 bucks was 66.43 (SE = 0.76; N = 107) kg (Table 2, p. 37). Group 2 bucks had a mean live body weight of 60.84 (SE = 0.79; N = 75) kg, and Group 1 had a mean live body weight of 53.81 (SE = 0.88; N = 56) kg. Of the Group 3 bucks, 85 (79%) weighed ≥ 60 kg, while 37 (49%) Group 2 bucks, and 13 (24%) Group 1 bucks weighed ≥ 60 kg. There was an 18.15 kg difference between the heaviest Group 3 buck (84.37 kg) and the heaviest Group 1 buck (66.22 kg). Of the Group 1 bucks, 19 (34%) weighed ≤ 50 kg, while 4 (5%) Group 2 bucks, and only 2 (2%) Group 3 bucks weighed ≤ 50 kg (Figure 7, p. 49). The mean live body weights for these 3 groups were significantly different ($P < 0.0001$) using the Ryan-Einot-Gabriel-Welsch multiple *F* test.

GBC COMPONENTS AMONG SPIKE-ANTLERED, 3-5 POINT, AND ≥ 6 POINT YEARLINGS AT 2.5 YEARS OF AGE

The means of GBC components were significantly different between the 3 groups of bucks (Table 2, p. 37). Spread measurements accounted for 17.6% (Group 1), 15.9% (Group 2), and 14.4% (Group 3) of the GBC scores for the 3 groups. The ΣMB measurements accounted for 37.8% (Group 1), 34.9% (Group 2), and 32.8% (Group 3) of the GBC scores. The ΣGn measurements accounted for 17.2% (Group 1), 24.8% (Group 2), and 28.9% (Group 3) of the GBC scores. The ΣHn measurements contributed 27.4% (Group 1), 24.3% (Group 2), and 22.6% (Group 3) of the GBC scores (Fig. 8, p. 50).

TOTAL ANTLER POINTS AMONG SPIKE-ANTLERED, 3-5 POINT, AND ≥ 6 POINT YEARLINGS AT 2.5 YEARS OF AGE

Yearlings with ≥ 6 points had significantly more total points than both Group 2 (3-5 points as yearlings) and Group 1 (spike-antlered as yearlings) bucks at 2.5 years of age. The mean total number of points for Group 1 bucks was 5.26 (SE = 0.24; N = 65), while the mean total points for Group 2 and Group 3 bucks were 7.01 (SE = 0.10; N =77) and 7.93 (SE = 0.13; N = 110), respectively (Table 2, p. 37). There was a significant difference between the mean total of points for the 3 groups ($P < 0.0001$). Of the 3 groups, 11 (17%) Group 1 bucks, 38 (49%) Group 2 bucks, and 77 (70%) Group 3 bucks had ≥ 8 total points. Of the Group 3 bucks, 10 (9%) had ≥10 points, while 1 (1%) Group 2 buck and zero Group 1 bucks had ≥ 10 points (Figure 9, p. 51).

JULIAN BIRTHDATES AMONG SPIKE-ANTLERED, 3-5 POINT, AND $\geq$ 6 POINT AS YEARLINGS AT 2.5 YEARS OF AGE

Group 1 bucks were born significantly later than both Group 2 bucks and Group 3 bucks. The mean Julian birthday for Group 1 bucks was day 182 (SE = 3.46), while the mean Julian birthday for Group 2 bucks and Group 3 bucks were days 171 (SE = 2.50) and 158 (SE = 1.85), respectively. There was a significant difference between the mean Julian birthdates for the 3 groups ($P < 0.0001$) using a Ryan-Einot-Gabriel-Welsch Multiple *F* test (Table 2, p. 37).

INCREASE IN GBC SCORES FROM 1.5 TO 2.5 YEARS OF AGE AMONG SPIKE-ANTLERED, 3-5 POINT, AND $\geq$ 6 POINT YEARLINGS

To determine if the three groups of bucks' GBC scores increased at similar rates, GBC scores at 1.5 and 2.5 years of age were examined to calculate changes of increase in GBC scores (ΔGBC). At 2.5 years of age, there were no significant differences in ΔGBC between the three groups of bucks. The mean increase in GBC scores from 1.5 to 2.5 years of age for Group 1 (spike-antlered as yearlings) bucks was 34.01 (SE = 1.91), while the mean change in GBC score from 1.5 to 2.5 years of age for Group 2 (3-5 points as yearlings) and Group 3 ($\geq$ 6 points as yearlings) were 36.02 (SE = 1.42) and 33.50 (SE = 1.18), respectively. The means of the three groups showed no significant differences

($P < 0.4$); Ryan-Einot-Gabriel-Welsch multiple *F* test (Table 2, p. 37).

CHANGE IN LIVE BODY WEIGHT FROM 1.5 TO 2.5 YEARS OF AGE AMONG SPIKE-ANTLERED, 3-5 POINT, AND $\geq$ 6 POINT YEARLINGS

Changes in live body weights (ΔWt) were calculated for the three groups of bucks, and there were no differences in ΔWt between the three groups of deer at 2.5 years of age. The mean change in live body weight from 1.5 to 2.5 years of age for Group 1 (spike-antlered as yearlings) bucks was 10.29 (SE = 0.67), while the mean change in live body weights from 1.5 to 2.5 years of age for Group 2 (3-5 points as yearlings) and Group 3 ($\geq$ 6 points as yearlings) were 11.57 (SE = 0.53) and 12.11 (SE = 0.46), respectively. A Ryan-Einot-Gabriel-Welsch multiple *F* test showed there were no significant differences in the mean change in live body weight between any of the three groups using ($P < 0.07$; Table 2, p. 37).

CORRELATION AMONG WEIGHT, GBC SCORES, AND GBC COMPONENTS AMONG SPIKE-ANTLERED, 3-5 POINT, AND $\geq$ 6 POINT YEARLINGS AT 2.5 YEARS OF AGE

Pearson correlation coefficients were calculated for all bucks (Table 3, p. 38), Group 1, Group 2, and Group 3 bucks at 2.5 years of age to determine which variables, such as weight at 1.5 and 2.5 years of age, GBC at 1.5 and 2.5 years of age, GBC components, total number of points, and Julian birthdate, were highly correlated. Correlation values for Group 1 are similar to SAY (both were spike-antlered as yearlings; Table 4, p. 39).

For Group 2 bucks, weights at 1.5 and 2.5 years were highly correlated (0.78). The GBC scores for Group 2 bucks at 2.5 years of age were highly correlated with ΣMB (0.89), ΣH_n (0.76), ΣG_n (0.93), and SP (0.69). GBC components that were highly correlated included ΣMB and ΣH_n (0.64), ΣMB and ΣG_n (0.72), ΣMB and SP (0.64), ΣG_n and ΣH_n (0.61), and the number of abnormal points and length of abnormal points (0.97; Table 6, p. 41).

For Group 3 bucks, weights at 1.5 and 2.5 years were highly correlated (0.80). The GBC scores for Group 3 bucks at 2.5 years of age were highly correlated with ΣMB (0.81), ΣH_n (0.83), ΣG_n (0.94), and SP (0.59). GBC components that were highly correlated included ΣMB and ΣH_n (0.59), ΣMB and ΣG_n (0.66), ΣMB and SP (0.61), ΣG_n and ΣH_n (0.76), and the number of abnormal points and length of abnormal points (0.79; Table 7, p. 42).

RELATIONSHIP OF GBC SCORES AT 2.5 YEARS OF AGE AND LIVE BODY WEIGHT AT 1.5 YEARS OF AGE FOR SAY BUCKS AND FAY BUCKS

The relationship between GBC scores at 2.5 years and live body weight at 1.5 years of age was investigated to determine the significance of live body weight at 1.5 years on GBC scores at 2.5 years of age. Linear regression was used to determine the overall best fit line for all 2.5 year old bucks combined, as well as best fit lines for SAY and FAY bucks (Figure 10, p. 52). Results showed the slope for all bucks combined to be significantly different from zero ($t = 13.25$, $df = 1$; $P < 0.0001$, $R^2 = 0.45$). A comparison of the slopes of the regression of GBC scores at 2.5 years of age and live body weight at 1.5 years of age for both SAY bucks and FAY bucks (Figure 10, p. 52) showed that the slopes for each were significantly different from zero ($t = 3.15$, $df = 1$; $P < 0.003$, $R^2 = 0.17$ for SAY bucks; $t = 8.46$, $df = 1$; $P < 0.0001$, $R^2 = 0.30$ for FAY bucks). However, the slopes of SAY bucks and FAY bucks were not significantly different from each other ($F = 0.57$, $P < 0.45$).

RELATIONSHIP OF GBC SCORES AT 2.5 YEARS OF AGE AND LIVE BODY WEIGHT AT 2.5 YEARS OF AGE FOR SAY BUCKS AND FAY BUCKS

The relationship between GBC scores at 2.5 years and live body weight at 2.5 years of age was investigated to determine the significance of live body weight at 2.5 years on GBC scores at 2.5 years of age. Linear regression was used to determine the overall best fit line for all 2.5 year old bucks combined, as well as best fit lines for SAY and FAY bucks (Figure 11, p. 53). Results showed the slope for all bucks combined to be significantly different from zero ($t = 13.72$, $df = 1$; $P < 0.001$, $R^2 = 0.45$). A comparison of the slopes of the regression of GBC scores at 2.5 years of age and live body weight at 2.5 years of age for both SAY bucks and FAY bucks (Figure 11, p. 53) showed that the slopes for each were significantly different from zero ($t = 3.45$, $df = 1$; $P < 0.001$, $R^2 = 0.19$ for SAY bucks; $t = 9.04$, $df = 1$; $P < 0.0001$, $R^2 = 0.32$ for FAY bucks). However, the slopes of SAY bucks and FAY bucks were not significantly different from each other ($F = 0.14$, $P < 0.70$).

RELATIONSHIP OF WEIGHT AT 2.5 YEARS OF AGE AND JULIAN BIRTHDATE FOR SAY BUCKS AND FAY BUCKS

The relationship between weight (kg) at 2.5 years and Julian birthdate was investigated to determine the significance of Julian birthdate on live body weight at 2.5 years of age. Linear regression was used to determine the overall best fit line for all 2.5

year old bucks combined, as well as best fit lines for SAY and FAY bucks (Figure 12, p. 54). Results showed the slope for all bucks combined to be significantly different from zero ($t = 2.97$, $df = 1$; $P < 0.003$, $R^2 = 0.04$). A comparison of the slopes of the regression of weight at 2.5 years of age and Julian birthdate for both SAY bucks and FAY bucks (Figure 12, p. 54) showed that the slopes for each were not significantly different from zero ($t = 0.97$, $df = 1$; $P < 0.34$, $R^2 = 0.02$ for SAY bucks; $t = 1.22$, $df = 1$; $P < 0.22$, $R^2 = 0.01$ for FAY bucks). Moreover, the slopes of SAY bucks and FAY bucks were not significantly different from each other ($F = 1.97$, $P < 0.16$).

RELATIONSHIP BETWEEN GBC SCORES AT 2.5 YEARS OF AGE AND JULIAN BIRTHDATE FOR SAY BUCKS AND FAY BUCKS

The relationship between GBC scores at 2.5 years of age and Julian birthdate was investigated to determine the significance of Julian birthdate on GBC scores at 2.5 years of age. Linear regression was used to determine the overall best fit line for all 2.5 year old bucks combined, as well as best fit lines for SAY and FAY bucks (Figure 13, p. 55). Results showed the slope for all bucks combined to be significantly different from zero ($t = 4.06$, $df = 1$; $P < 0.0001$, $R^2 = 0.07$). A comparison of the slopes of the regression of GBC scores at 2.5 years of age and Julian birthdate for both SAY bucks and FAY bucks (Figure 13, p. 55) showed that the slopes for each were not significantly different from zero ($t = 1.10$, $df = 1$; $P < 0.27$, $R^2 = 0.02$ for SAY bucks; $t = 1.71$, $df = 1$; $P < 0.09$, $R^2 = 0.02$ for FAY bucks). Moreover, the slopes of SAY bucks and FAY bucks were not significantly different from each other ($F = 3.48$, $P < 0.06$).

DISCUSSION

Hypotheses stating no differences in antler characteristics and live body weights between spike-antlered and fork-antlered yearlings at 2.5 years of age were tested and rejected. Results from this study indicate that 2.5 year old bucks, maintained under standardized nutritional conditions, exhibited large differences in both antler characteristics and live body weights between bucks that were spike-antlered as yearlings, and bucks that were fork-antlered as yearlings. The mean GBC score for FAY bucks was 28.7 points (inches) higher than the mean GBC score for SAY bucks. FAY bucks also had significantly higher GBC component scores (inches), and number of total points (typical and atypical) than SAY bucks. Comparison of live body weights between SAY bucks and FAY bucks showed similar results, with FAY bucks having a mean live body weight 10.3 kg (22.7 lbs) heavier than the mean live body weight of SAY bucks. These results are consistent with other publications, comparing the two groups at other age classes, stating differences between antler characteristics and live body weights of bucks that were spike-antlered as yearlings, and bucks that were fork-antlered as yearlings(Hendrix, 1998; Ott et al., 1998; Roberts, 1996; Armstrong et al., 1994; Harmel et al., 1989).

There was a strong relationship between GBC score at 2.5 years of age and live body weight at 2.5 years of age, as well as between GBC score at 2.5 years of age and live body weight at 1.5 years of age. Differences in live body weight at ages 1.5 and 2.5 accounted for almost half ($R^2 = 0.45$) of the total variation in GBC scores at 2.5 years of age. This indicates that antler size and configuration increase with respect to increases in live body weight. Also, if live body weight is an index of body condition, then body condition strongly affects antler size and configuration. These results concur with previous studies on the relationship between antler characteristics and live body weight (Hendrix, 1998; Ott et al., 1997; Roberts, 1996; Schultz and Johnson, 1992; Harmel et al., 1989). Based on analysis of the data from this study, the null hypothesis stating no differences exist in live body weight or antler characteristics between bucks at 2.5 years of age, that were either spike-antlered or fork-antlered as yearlings, was rejected.

To determine if the SAY and FAY classification was an over simplification for the comparison of live body weights and antler characteristics, bucks were also classified into three groups based on the number of tines present at 1.5 years of age (Hendrix, 1998; Ott et al., 1997). Hendrix (1998) found significant differences in live body weight and antler characteristics between yearling (1.5 years of age) bucks that were spike-antlered, had 3-5 points, or $\geq$ 6 points. Ott et al. (1997) found similar differences in live body weight and antler characteristics for these classes of deer at maturity (4.5 years of age). Results from this study concur with Hendrix (1998), Ott et al. (1997), and Williams et al. (1983) in that there are significant differences in live body weight and antler characteristics between bucks at 2.5 years of age that as yearlings, were spike-antlered, had 3-5 points, or $\geq$ 6 points. Bucks with $\geq$ 6 points as yearlings had a mean GBC score that was 17.21 points higher than bucks with 3-5 points as yearlings, and 35.79 points higher than bucks that were spike-antlered as yearlings. Also, bucks with $\geq$ 6 points as yearlings had significantly higher GBC component scores, as well as number of total points (typical and atypical), than the other two groups of bucks.

Comparison of mean live body weights for the three groups showed similar results. Bucks with $\geq$ 6 points as yearlings had a mean live body weight 5.59 kg heavier than bucks with 3-5 points as yearlings, and 12.62 kg (27.8 lbs) heavier than spike-antlered bucks as yearlings. Therefore, the null hypothesis stating no difference exists in live body weight and antler characteristics between 2.5 year old bucks that as yearlings, were spike- antlered, 3-5 points, or ≥ 6 points, was rejected.

The percent contribution of GBC components to the GBC scores was examined for all categories of bucks (two-class and three-class). The spread component contributed the least to overall GBC scores for all categories of bucks at 2.5 years of age. Circumference measurements contributed the most to the overall GBC scores of bucks that were spike-antlered as yearlings. For all bucks other than spike-antlered as yearlings, length measurements (main beam and tine) contributed most to the overall GBC score. These results are consistent with the percent contribution of GBC components to overall GBC scores found by Hendrix (1998) with 1.5 year old (yearling) bucks.

Birthdate is one factor commonly believed to cause spike-antlered yearlings (Schultz and Johnson, 1992). To determine if birthdate was a factor affecting antler growth and body mass, date of birth was also examined for the two-class and three-class antler configurations. Results show that spike-antlered yearlings were born significantly later than fork-antlered yearlings. Also, when put into a three-class analysis, bucks with ≥ 6 points as yearlings were born 13 days earlier than bucks with 3-5 points as yearlings, and 24 days earlier than bucks that were spike-antlered as yearlings.

I also examined the relationships of Julian birthdate and GBC score at 2.5 years of age and Julian birthdate and live body weight at 2.5 years of age. In both cases, the relationships with Julian birthdates were significant for all deer combined. However, when these relationships were examined between spike-antlered and fork-antlered bucks separately, there was no significant relationship between Julian birthdates and GBC or live body weight. Also, Julian birthdate accounted for very little of the total variation in GBC score ($R^2 = 0.07$) and live body weight ($R^2 = 0.04$) in 2.5 year old white-tailed bucks. This data concurs with Hendrix (1998), and based on data from this study and Hendrix (1998), birthdate alone is not a solid explanation for the presence of spike-antlered deer in a population. However, bucks used in this study were maintained under optimal nutritional conditions year round. Due to these conditions, the theory of bucks born late having less time to feed on forage before nutritional values decrease due to winter dormancy (Jacobson, 1995) could not be addressed.

It is believed by some that spike-antlered bucks are not inferior to fork-antlered bucks, and that spike-antlered bucks, if given a chance, will "catch up" to their fork-antlered cohorts in later years. To address the issue of spike-antlered bucks "catching up" to their fork-antlered cohorts, ΔGBC (change in GBC from 1.5 years to 2.5 years of age) and Δweight (change in live body weight from 1.5 years to 2.5 years of age) were examined for the two-class and three-class analyses. In both cases, the change in GBC scores and the change in live body weights were insignificant when examined between all the classes. These data show that spike-antlered and fork-antlered bucks gain similar weight and antler growth from 1.5 to 2.5 years of age, thus eliminating the possibility of a spike-antlered buck to "catch up" to a fork antlered buck in either live body weight or antler growth during this time period.

MANAGEMENT IMPLICATIONS

Wildlife management strategies for white-tailed deer can vary in many ways. However, there are a few crucial steps in implementing a management plan for quality antler production. The first and most crucial step involves the control of deer density. Deer populations must be reduced to a level conforming to the available food resources in their habitat. This level, known as the biological carrying capacity, can sometimes be difficult to determine due to ever changing environmental factors. Once deer populations are reduced to this level, or near this level, there is less competition for desirable forage, as well as a decrease in overutilization of food resources.

While in the process of reducing deer herd densities, one must also look at the condition of the habitat which these deer inhabit. Factors such as overgrazing and suppression of wildfires have led to the encroachment of many undesirable woody plant species in areas throughout Texas. However, methods such as prescribed burning, chemical treatment, and mechanical manipulation of undesirable woody plant species can help to reduce the amount of these woody species, creating a mosaic of more desirable woody species as well as forbs and grasses.

Habitats containing mosaics of desirable woody plants, forbs, and grasses provide greater potential for higher nutritional values than habitats dominated by a few undesirable species. By reducing deer populations, and improving deer habitat, the probability of producing quality white-tailed bucks increases due to increased nutrition necessary to achieve their genetic potential.

Another method of white-tailed deer management is culling bucks with undesirable antler characteristics. Based on the results of this study, as well as results of Hendrix

(1998) and Ott et al. (1997), spike-antlered bucks have lower live body weights and smaller antler characteristics when compared to fork-antlered bucks. Since these traits are moderate to highly heritable (Williams et al. 1994), removal of spike-antlered bucks from a population will reduce the frequency of these inferior qualities in the herd. Also, by selectively removing spike-antlered bucks from the herd, the mean live body weight and mean antler characteristics will shift toward a more desirable level. This shift can easily be monitored by recording harvest data such a live body weight, and antler measurements such a gross Boone and Crockett measurements.

A more intensive approach to management is to cull more specifically than spike- or fork-antlered bucks. For example, bucks with less than six points can be removed, which should drastically move the mean live body weight and antler characteristics to higher values. However, while increasing live body weights and antler characteristics, this intensity of management may reduce the total number of quality white-tailed bucks available for harvest at maturity.

Data from this study, along with the results of Hendrix (1998), Ott et al. (1997), and Harmel et al. (1989) show a significant difference between live body weight and antler characteristics of spike-antlered and fork-antlered bucks under controlled optimum conditions. This data also shows that birthdate alone is not a solid explanation for the presence of spike-antlered bucks in a population. Although removal of spike-antlered bucks from a population is recommended to increase mean live body weights and antler size of bucks, and reduce the frequency of inferior antler traits and body weights within the population, it is still up to individual landowners and managers to evaluate herd density and habitat quality to decide what management strategies, and at what intensity of management they want to implement on their white-tailed deer herds.

Literature Cited

Armstrong, W.E. 1991. Managing habitat for white-tailed deer in the Hill Country area of Texas. Texas Parks and Wildlife Department. PWD-RP-7100-193.

Armstrong, W.E., D.E. Harmel, B. Young, and F. Harwell. 1994. The management of spike bucks. Texas Parks and Wildlife Departments, leaflet N7100-247.

Asleson, M.A., E.C. Hellgren, and L.W. Varner. 1996. Nitrogen requirements for antler growth and maintenance in white-tailed deer. Journal of Wildlife Management, 60:744-752.

Baxter, D., D.E. Harmel, W.E. Armstrong, and G. Butts. 1981. Spikes vs. forked-antlered bucks. Texas Parks and Wildlife Department, leaflet 9000-105.

Boone and Crockett. 1981. Official scoring system for North American big game trophies. Boone and Crockett Club. Alexandria, VA.

Brothers, A., D.C. Guynn, Jr., J. Hamilton, and R.L. Marchinton. 1995. The spike question. Pp 112-117, *in* Quality whitetails: the why and how of quality deer management (K.V. Miller and R.L. Marchinton, eds.). Stackpole Books, Mechanicsburg, PA.

Cook, R.L. 1984. Texas. Pp 457-474, *in* White-tailed deer: ecology and management (L.K. Halls, ed.). Stackpole Books, Harrisburg, PA.

Cox, J. 1982 Big Charlie was no ordinary deer. Texas Parks and Wildlife Department, leaflet C2000-106.

Forand, K.J., R.L. Marchinton, and K.V. Miller. 1985. Influence in dominance rank on the antler cycle of white-tailed deer. Journal of Mammalogy, 66:58-62.

Grasman, B.T. and E.C. Hellgren. 1993. Phosphorus nutrition in white-tailed deer: nutrient balance, physiological responses, and antler growth. Ecology, 74:2279-2296.

Gray, P.B. and F.A. Servello. 1995. Energy intake relationships for white-tailed deer on winter browse diets. Journal of Wildlife Management, 59:147-152.

Harmel, D.E. 1983. Effects of genetics on antler quality and body size in white-tailed deer. Pp 339-347, *in* Antler development in Cervidae (R.D. Brown, ed.). Caesar Kleberg Wildlife Institute, Kingsville, Texas.

Harmel, D.E., J.D. Williams, and W.E. Armstrong. 1989. Effects of genetic and nutrition on antler development and body size of white-tailed deer. Final Report, Texas Parks and Wildlife. 7100-155.

Hendrix, Jr, P.G. 1998. Comparison of antler characteristics and body weights of white-tailed deer at 1.5 years of age. Master of Science Thesis, Southwest Texas State University, San Marcos, Texas.

Jacobson, H.A. 1995. Age and quality relationships. Pp 103-111 *in* Quality whitetails: the why and how of quality deer management (K.V. Miller and R.L. Marchinton, eds.). Stackpole Books, Mechanicsburg, PA.

Langenau Jr, E.E, S.R. Kellert, and J.E. Applegate. 1984. Values in management. Pp 699-720 , *in* White-tailed deer: ecology and management (L.K. Halls, ed.). Stackpole Books, Harrisburg, PA.

Marchinton, R.L., K.V. Miller, and J.S. McDonald. 1995. Genetics. Pp 169-189 *in* Quality whitetails: the why and how of quality deer management (K.V. Miller and R.L. Marchinton, eds.). Stackpole Books, Mechanicsburg, PA.

Miller, K.V., R.L. Marchinton, and J.R. Beckwith. 1985. Variations in density and chemical composition of white-tailed deer antlers. Journal of Mammology, 66:693-701.

Ott, J.R., S.W. Roberts, J.T. Baccus, D.E. Harmel, W.E. Armstrong, and E. Fuchs. 1997. Antler characteristics and body mass of spike- and fork-antlered yearling white-tailed deer at maturity. Proceeding of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies, 51:400-413.

Ott, J.R., J.T. Baccus, and S.W. Roberts. 1998. The comparative performance of spike- and fork-antlered yearling white-tailed deer: the basis for selection. Pp 22-32 *in* The role of genetics in white-tailed deer management (K.A. Cearly and D. Rollins, eds). Texas A&M University, College Station, TX.

Ozoga, J.J. 1988. Incident of "infant" antlers among supplementally-fed white-tailed deer. Journal of Mammalogy, 69:393-395.

Roberts, S.W. 1996. Comparison of antler measurements and body weights of fork-antlered and spike-antlered white-tailed deer at 4.5 years of age. Master of Science Thesis, Southwest Texas State University, San Marcos, Texas.

Sauer, P.R. 1984. Physical characteristics. Pp 73-90 *in* White-tailed deer: ecology and management (L.K. Halls, ed.). Stackpole Books, Harrisburg, PA.

Schultz, S.R., and M.K. Johnson. 1992. Chronology of velvet shedding in captive Louisiana white-tailed deer. Journal of Wildlife Management, 56:651-655.

Schultz, S.R., and M.K. Johnson. 1995. Effects of birthdate and body mass at birth on adult body mass of male white-tailed deer. Journal of Mammalogy, 76:575-579.

Scribner, K.T., M.H. Smith, and P.E. Johns. 1989. Environmental and genetic components in antler growth in white-tailed deer. Journal of Mammalogy, 70:284-291.

Ullrey, D.E. 1982. Nutrition and antler development in white-tailed deer. Pp 49-60, *in* Antler Development in the Cervidae (R.D. Brown, ed.). Stackpole Books, Harrisburg, PA.

Verme, L.J., and D.E. Ullrey. 1984 Physiology and Nutrition. Pp 91-118, 90 *in* White-tailed deer: ecology and management (L.K. Halls, ed.). Stackpole Books, Harrisburg, PA.

Weeks, Jr., H.P. 1995. Mineral supplementation for antler production. Pp 155-168 *in* Quality whitetails: the why and how of quality deer management (K.V. Miller and R.L. Marchinton, eds.). Stackpole Books, Mechanicsburg, PA.

Williams, J.D., D.E. Harmel, W.E. Armstrong, and S.E. Wardroup. 1983. Antler development in the white-tailed deer. Page 468, *in* Antler Development in the Cervidae (R.D. Brown, ed.). Stackpole Books, Harrisburg, PA.

Williams, J.D., W.F. Kreuger, and D.E. Harmel. 1994. Heritabilities for antler characteristics and body weight in yearling white-tailed deer. Heredity, 73:78-83.

Table 1. Comparison of mean weight (kg), Gross Boone and Crockett (GBC) scores (inches), GBC component scores, and change in weight and GBC from 1.5 to 2.5 years between spike- and fork-antlered yearling white-tailed deer at 2.5 years of age.

	Spike- antlered			Fork- antlered			
Variables(a)	N	$\bar{x}$	SE	N	$\bar{x}$	SE	P > T
Wt	56	53.81	0.88	182	64.13	0.59	0.0001
GBC	63	63.80	2.21	183	92.54	1.24	0.0001
SP	63	11.23	0.32	183	13.85	0.16	0.0001
ΣMB	65	23.90	0.79	187	31.09	0.32	0.0001
ΣG_n	65	10.81	0.99	187	25.34	0.66	0.0001
ΣH_n	65	17.39	0.35	187	21.49	0.19	0.0001
ABPTS	65	0.04	0.03	187	0.53	0.13	0.0006
Δ GBC	47	34.03	1.91	171	34.52	0.91	0.82
Δ Wt	52	10.29	0.67	171	11.89	0.35	0.03
Points	65	5.26	0.24	187	7.55	0.10	0.0001
Birthdate	56	182.0	3.46	184	163.3	1.57	0.0001

a. Variables for both Table 1 and 2 are Wt = live body weight in kg; GBC = gross Boone and Crockett score in inches; SP = greatest inside spread between left and right antlers; ΣMB = combined length of left and right main beams; ΣG_n = combined length of all typical tines on right and left antler; ΣH_n = combined circumference of the four measurement positions of both right and left antler; ABPTS = combined length of all abnormal (atypical) points on right and left antler; ΔGBC = change in GBC score from 1.5 years of age to 2.5 years of age; ΔWt = change of live body weight from 1.5 years of age to 2.5 years of age; Points = number of typical and aytpical (abnormal) points of both left and right antler at 2.5 years of age; Birthdate = Julian birthdate.

Table 2. Comparison of weight (kg) , GBC scores (inches), GBC component scores, and change in weight and GBC scores from 1.5 to 2.5 years between Group 1 (spike-antlered as yearlings), Group 2 (3-5 points as yearlings), and Group 3 (≥ 6 points as yearlings) white-tailed deer at 2.5 years of age. Results based on ANOVA followed by a means comparison using Ryan-Einot-Gabriel-Welsch multiple *F* test. Means followed by different letters indicate a significant difference (P = 0.05).

	Spike-antlered			3-5 pts			≥ 6 pts				
Variables(1)	N	$\bar{x}$	SE	N	$\bar{x}$	SE	N	$\bar{x}$	SE	R^2	P > F
Wt	56	53.81_a	0.88	75	60.84_b	0.79	107	66.43_c	0.76	0.32	0.0001
GBC	63	63.80_a	2.21	75	82.38_b	1.56	108	99.59_c	1.45	0.48	0.0001
SP	63	11.23_a	0.32	75	13.16_b	0.24	108	14.32_c	0.02	0.24	0.0001
ΣMB	65	23.90_a	0.79	77	28.83_b	0.47	110	32.67_c	0.36	0.37	0.0001
ΣG_n	65	10.81_a	0.99	77	20.39_b	0.81	110	28.80_c	0.83	0.45	0.0001
ΣH_n	65	17.39_a	0.35	77	20.02_b	0.24	110	22.52_c	0.25	0.40	0.0001
ABPTS	65	0.04_a	0.03	77	0.09_b	0.07	110	0.83_c	0.22	0.05	0.001
ΔGBC	47	34.01_a	1.91	69	36.02_a	1.42	102	33.50_a	1.18	0.01	0.4
ΔWt	52	10.29_a	0.67	68	11.57_a	0.53	103	12.11_a	0.46	0.02	0.07
Points	65	5.26_a	0.24	77	7.01_b	0.10	110	7.93_c	0.13	0.33	0.0001
Birthdate	56	182_a	3.46	75	171_b	2.50	109	158_c	1.85	0.17	0.0001

1. Variable notations are the same as stated in Table 1

Table 3. Pearson Correlation coefficients (r, above), significance level (* = ≤ 0.001; ** = ≤ 0.05 ; ^{ns} = not significant) and N (below) of live body weight (kg) at 1.5 and 2.5 years of age, GBC scores (inches) for 1.5 and 2.5 years of age, and GBC components for all 2.5 year old white-tailed bucks in the Kerr Wildlife Management Area deer herd, Kerr County, Texas.

	GBC1	**GBC2**	**ΔGBC**	**BD**	**Wt1**	**Wt2**	**ΔWt**	**ΣMB**	**ΣH_n**	**ΣG_n**	**SP**	**Nabpts**	**Ablen**
Ptsyr2	0.61* 221	0.84* 246	0.52* 218	-0.21** 240	0.48* 224	0.52* 238	0.27* 223	0.74* 252	0.73* 252	0.85* 252	0.57* 246	0.44* 252	0.33* 252
GBC1		0.81* 218	-0.08^{NS} 218	-0.45* 220	0.72* 214	0.63* 220	0.10^{NS} 213	0.77* 221	0.75* 221	0.76* 221	0.62* 218	0.24* 221	0.24* 221
GBC2			0.52* 218	-0.26* 235	0.67* 219	0.67* 233	0.27* 218	0.93* 246	0.90* 246	0.96* 246	0.76* 246	0.37* 246	0.36* 246
ΔGBC				0.24* 217	0.08^{NS} 211	0.24* 217	0.32* 210	0.44* 218	0.42* 218	0.52* 218	0.36* 218	0.29* 218	0.28* 218
BD					-0.29* 222	-0.19** 233	0.06^{NS} 221	-0.27* 240	-0.24* 240	-0.24* 240	-0.22* 235	-0.10^{NS} 240	-0.09^{NS} 240
Wt1						0.85* 223	0.08^{NS} 223	0.64* 224	0.64* 224	0.61* 224	0.62* 219	0.23* 224	0.22* 224
Wt2							0.59* 223	0.62* 238	0.66* 238	0.62* 238	0.58* 233	0.26* 238	0.22* 238
ΔWt								0.20** 223	0.30* 223	0.26* 223	0.19** 218	0.21** 223	0.14** 223
ΣMB									0.79* 252	0.82* 252	0.77* 246	0.25* 252	0.21* 252
ΣH_n										0.84* 252	0.65* 246	0.34* 252	0.29* 252
ΣG_n											0.61* 246	0.32* 252	0.24* 252
SP												0.15** 246	0.14** 246
Nabpts													0.81* 252

Table 4. Pearson Correlation coefficients (r, above), significance level (* = $\leq$ 0.001; ** = $\leq$ 0.05 ; ^{ns} = not significant) and N (below) of live body weight (kg) at 1.5 and 2.5 years of age, GBC scores (inches) for 1.5 and 2.5 years of age, and GBC components for SAY (spike-antlered as yearlings) white-tailed bucks in the Kerr Wildlife Management Area deer herd, Kerr County, Texas.

	GBC1	**GBC2**	**ΔGBC**	**BD**	**Wt1**	**Wt2**	**ΔWt**	**ΣMB**	**ΣH$_n$**	**ΣG$_n$**	**SP**	**Nabpts**	**Ablen**
Ptsyr2	0.41** 48	0.84* 63	0.71* 47	0.09^{NS} 56	0.26^{NS} 52	0.35** 56	0.15^{NS} 52	0.74* 65	0.69* 65	0.89* 65	0.51* 63	0.20^{NS} 65	0.21^{NS} 65
GBC1		0.56* 47	-0.05^{NS} 47	-0.22^{NS} 48	0.51** 46	0.32** 48	-0.21^{NS} 46	0.58* 48	0.51* 48	0.38** 48	0.63* 47	-0.004^{NS} 48	-0.004^{NS} 48
GBC2			0.79* 47	0.15^{NS} 55	0.41** 50	0.43** 54	0.09^{NS} 50	0.95* 63	0.88* 63	0.92* 63	0.75* 63	0.39** 63	0.39** 63
ΔGBC				0.36** 47	0.17^{NS} 45	0.35** 45	0.28^{NS} 45	0.71* 47	0.63* 47	0.83* 47	0.39** 47	. 47	. 47
BD					0.03^{NS} 50	0.13^{NS} 54	0.08^{NS} 50	0.11^{NS} 56	0.11^{NS} 56	0.17^{NS} 56	0.07^{NS} 55	-0.10^{NS} 56	-.10^{NS} 56
Wt1						0.70* 52	-0.22^{NS} 52	0.43** 52	0.35** 52	0.32** 52	0.49* 50	-0.05^{NS} 52	-0.05^{NS} 52
Wt2							0.54* 52	0.42** 56	0.44* 56	0.37** 56	0.39** 54	0.04^{NS} 56	0.04^{NS} 56
ΔWt								0.04^{NS} 52	0.15^{NS} 52	0.12^{NS} 52	0.01^{NS} 50	0.12^{NS} 52	0.12^{NS} 52
ΣMB									0.79* 65	0.79* 65	0.80* 63	0.26** 65	0.29** 65
ΣH$_n$										0.78* 65	0.60* 63	0.31** 65	0.36** 65
ΣG$_n$											0.50* 63	0.28** 65	0.31** 65
SP												0.28** 63	0.28** 63
Nabpts													0.98* 65

Table 5. Pearson Correlation coefficients (r, above), significance level (* = ≤ 0.001; ** = ≤ 0.05 ; ^{ns} = not significant) and N (below) of live body weight (kg) at 1.5 and 2.5 years of age, GBC scores (inches) for 1.5 and 2.5 years of age, and GBC components for FAY (fork-antlered as yearlings) white-tailed bucks in the Kerr Wildlife Management Area deer herd, Kerr County, Texas.

	GBC1	**GBC2**	**ΔGBC**	**BD**	**Wt1**	**Wt2**	**ΔWt**	**ΣMB**	**ΣH$_n$**	**ΣG$_n$**	**SP**	**Nabpts**	**Ablen**
Ptsyr2	0.44* 173	0.74* 183	0.56* 171	-0.10^{NS} 184	0.28* 172	0.35* 182	0.26* 171	0.55* 187	0.59* 187	0.76* 183	0.39* 183	0.56* 187	0.38* 187
GBC1		0.72* 171	-0.15^{NS} 171	-0.36* 172	0.62* 168	0.50* 172	0.04^{NS} 167	0.68* 173	0.65* 173	0.65* 173	0.48* 171	0.23** 173	0.22** 173
GBC2			0.59* 171	-0.13^{NS} 180	0.55* 169	0.59* 179	0.26* 168	0.88* 183	0.85* 183	0.95* 183	0.65* 183	0.40* 183	0.39* 183
ΔGBC				0.23** 170	0.05^{NS} 166	0.24** 170	0.34* 165	0.46* 171	0.46* 171	0.58* 171	0.39* 171	0.34* 171	0.33* 171
BD					-0.21** 172	-0.09^{NS} 179	0.13^{NS} 171	-0.20** 184	-0.14^{NS} 184	-0.12^{NS} 184	-0.12^{NS} 180	-0.07^{NS} 184	-0.05^{NS} 184
Wt1						0.82* 171	0.07^{NS} 171	0.52* 172	0.51* 172	0.46* 172	0.48* 169	0.22** 172	0.20** 172
Wt2							0.63* 171	0.50* 182	0.56* 182	0.49* 182	0.48* 179	0.25** 182	0.20** 182
ΔWt								0.19** 171	0.31* 171	0.25** 171	0.19** 168	0.22** 171	0.14^{NS} 171
ΣMB									0.68* 187	0.74* 187	0.65* 183	0.25** 187	0.19** 187
ΣH$_n$										0.77* 187	0.52* 183	0.36* 187	0.29* 187
ΣG$_n$											0.48* 183	0.32* 187	0.22** 187
SP												0.09^{NS} 183	0.09^{NS} 183
Nabpts													0.81* 187

Table 6. Pearson Correlation coefficients (r, above), significance level (* = $\leq$ 0.001; ** = $\leq$ 0.05 ; ^{ns} = not significant) and N (below) of live body weight (kg) at 1.5 and 2.5 years of age, GBC scores (inches) for 1.5 and 2.5 years of age, and GBC components for Group 2 (3-5 points as yearlings) white-tailed bucks in the Kerr Wildlife Management Area deer herd, Kerr County, Texas.

	GBC1	**GBC2**	**ΔGBC**	**BD**	**Wt1**	**Wt2**	**ΔWt**	**ΣMB**	**ΣH_n**	**ΣG_n**	**SP**	**Nabpts**	**Ablen**
Ptsyr2	0.29** 69	0.71* 75	0.61* 69	-0.08^{NS} 75	0.03^{NS} 68	0.16^{NS} 75	0.26** 68	0.52* 77	0.40** 77	0.80* 77	0.35** 75	0.15^{NS} 77	0.18^{NS} 77
GBC1		0.52* 69	-0.15^{NS} 69	-0.13^{NS} 68	0.23^{NS} 65	0.09^{NS} 69	-0.12^{NS} 65	0.48* 69	0.38** 69	0.48* 69	0.37** 69	0.24^{NS} 69	0.24^{NS} 69
GBC2			0.76* 69	-0.01^{NS} 73	0.28** 67	0.36** 74	0.26** 67	0.89* 75	0.76* 75	0.93* 75	0.69* 75	0.00^{NS} 75	0.07^{NS} 75
ΔGBC				0.11^{NS} 68	0.14^{NS} 65	0.35** 69	0.41** 65	0.68* 69	0.60* 69	0.71* 69	0.53* 69	0.10^{NS} 69	0.10^{NS} 69
BD					-0.04^{NS} 68	0.15^{NS} 73	0.29** 68	-0.01^{NS} 75	0.17^{NS} 75	-0.04^{NS} 75	-0.08^{NS} 73	-0.00^{NS} 75	-0.00^{NS} 75
Wt1						0.78* 68	0.11^{NS} 68	0.27** 68	0.27** 68	0.22^{NS} 68	0.29** 67	-0.05^{NS} 68	-0.05^{NS} 68
Wt2							0.70* 68	0.29** 75	0.37** 75	0.32** 75	0.33** 74	-0.13^{NS} 75	-0.13^{NS} 75
ΔWt								0.17^{NS} 68	0.30** 68	0.25** 68	0.17^{NS} 67	-0.04^{NS} 68	-0.04^{NS} 68
ΣMB									0.64* 77	0.72* 77	0.64* 75	-0.06^{NS} 77	-0.02^{NS} 77
ΣH_n										0.61* 77	0.53* 75	-0.06^{NS} 77	-0.03^{NS} 77
ΣG_n											0.48* 75	0.01^{NS} 77	0.08^{NS} 77
SP												-0.14^{NS} 75	-0.06^{NS} 75
Nabpts													0.97* 77

Table 7. Pearson Correlation coefficients (r, above), significance level (* = ≤ 0.001; ** = ≤ 0.05 ; ^{ns} = not significant) and N (below) of live body weight (kg) at 1.5 and 2.5 years of age, GBC scores (inches) for 1.5 and 2.5 years of age, and GBC components for Group3 (≥ 6 points as yearlings) white-tailed bucks in the Kerr Wildlife Management Area deer herd, Kerr County, Texas.

	GBC1	**GBC2**	**ΔGBC**	**BD**	**Wt1**	**Wt2**	**ΔWt**	**ΣMB**	**ΣH_n**	**ΣG_n**	**SP**	**Nabpts**	**Ablen**
Ptsyr2	0.34** 104	0.71* 108	0.65* 102	0.04^{NS} 109	0.26** 104	0.35** 107	0.25** 103	0.47* 110	0.61* 110	0.69* 110	0.32** 108	0.68* 110	0.43* 110
GBC1		0.63* 102	-0.07^{NS} 104	-0.27** 104	0.66* 103	0.56* 103	0.07^{NS} 102	0.65* 104	0.59* 104	0.55* 104	0.46* 102	0.12^{NS} 104	0.11^{NS} 104
GBC2			0.73* 102	0.09^{NS} 107	0.52* 102	0.53* 105	0.27** 101	0.81* 108	0.83* 108	0.94* 108	0.59* 108	0.46* 108	0.45* 108
ΔGBC				0.29** 102	0.08^{NS} 101	0.26** 101	0.31** 100	0.49* 102	0.56* 102	0.73* 102	0.38* 102	0.48* 102	0.45* 102
BD					-0.14^{NS} 104	-.08^{NS} 106	0.05^{NS} 103	-0.15^{NS} 109	-0.10^{NS} 109	0.06^{NS} 109	-0.03^{NS} 107	0.00^{NS} 109	0.02^{NS} 109
Wt1						0.80* 103	0.02^{NS} 103	0.51* 104	0.47* 104	0.40* 104	0.49* 102	0.18^{NS} 104	0.17^{NS} 104
Wt2							0.61* 103	0.49* 107	0.53* 107	0.43* 107	0.49* 107	0.28** 107	0.21** 107
ΔWt								0.19** 103	0.33** 103	0.25** 103	0.18^{NS} 101	0.28** 103	0.17^{NS} 103
ΣMB									0.59* 110	0.66* 110	0.61* 108	0.27** 110	0.18^{NS} 110
ΣH_n										0.76* 110	0.44* 108	0.39* 110	0.28** 110
ΣG_n											0.39* 108	0.33** 110	0.17^{NS} 110
SP												0.09^{NS} 108	0.08^{NS} 108
Nabpts													0.79* 110

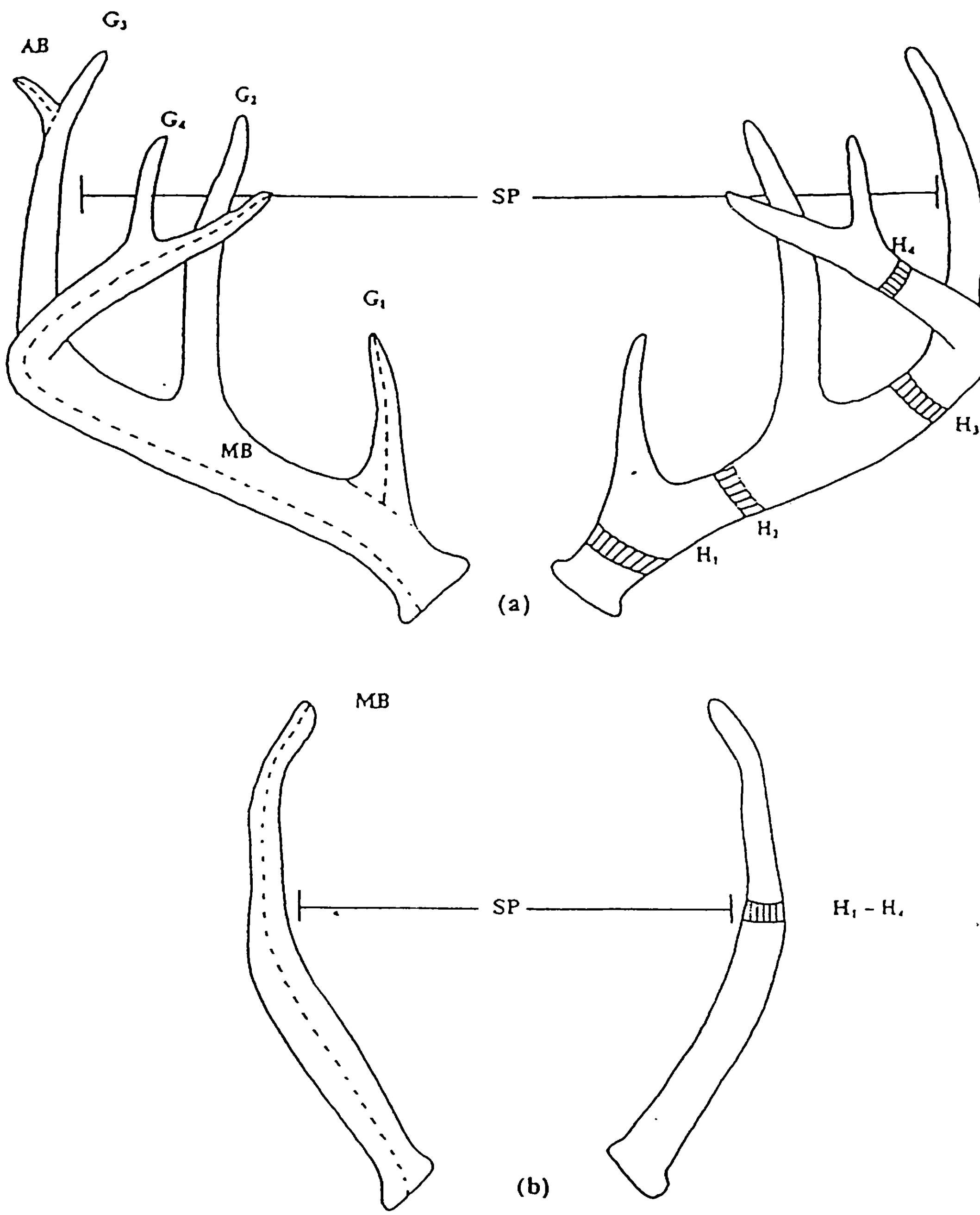

Figure 1. Diagram showing views of antler measurements used in calculating gross Boone and Crockett (GBC) scores for (a) fork-antlered bucks and (b) spike-antlered bucks. SP is the greatest inside measurement between the left and right main beams; MB is the main beam length; G_1-G_4 are the typical tine lengths; H_1-H_4 are the circumference measurements; AB is the abnormal (atypical) tine length.

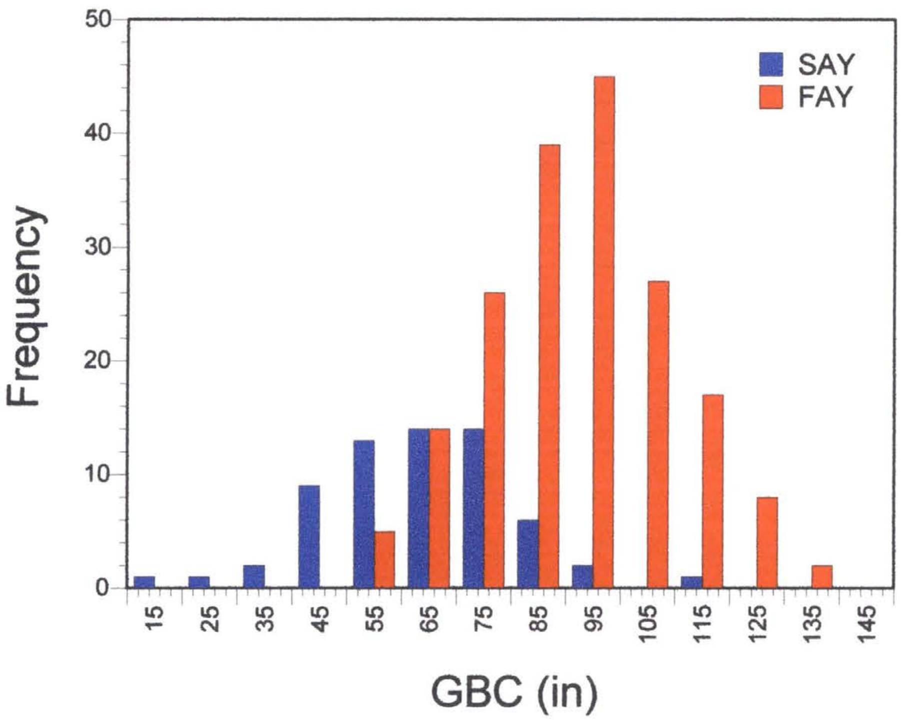

Figure 2. Distribution of gross Boone and Crockett (GBC) scores for SAY (spike-antlered as yearlings; N = 63) and FAY (fork-antlered as yearlings; N = 183) white-tailed bucks at 2.5 years of age in the Kerr Wildlife Management Area deer herd, Kerr County, Texas.

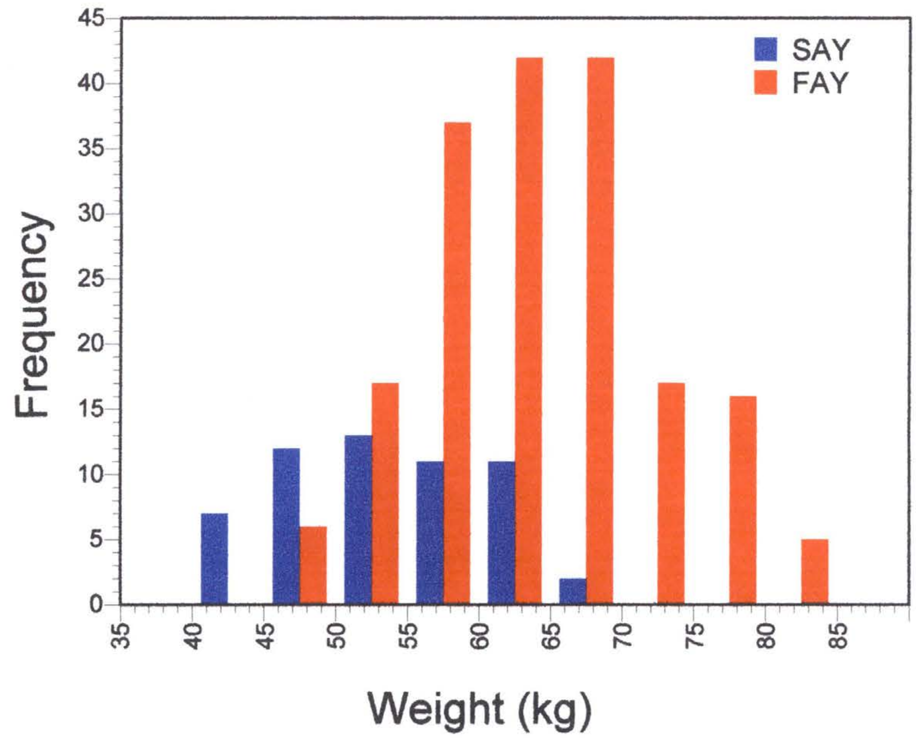

Figure 3. Distribution of live body weights of SAY (spike-antlered as yearlings; N = 56) and FAY (fork-antlered as yearlings; N = 182) white-tailed bucks at 2.5 years of age in the Kerr Wildlife Management Area deer herd, Kerr County, Texas.

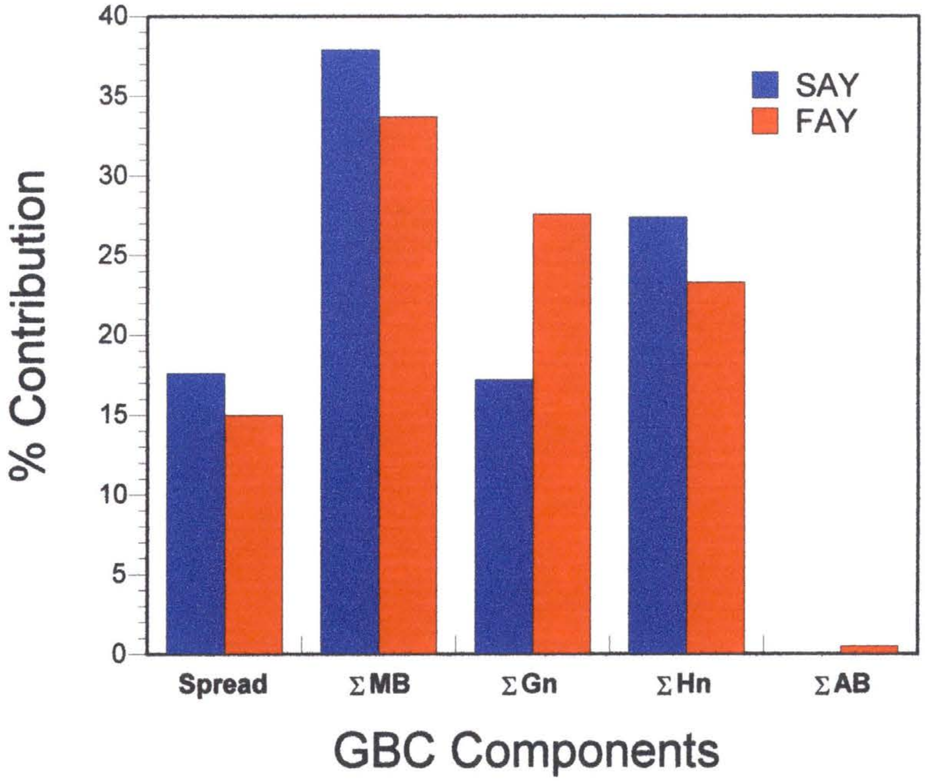

Figure 4. Percent compositions of GBC components (Spread = maximum inside spread between right and left antlers; ΣMB = combined length of right and left main beams; ΣG_n = combined length of all typical tines on right and left antler; ΣH_n = combined circumference of the four measurement positions of both right and left antler; ΣAB = combined length of all abnormal (atypical) points on right and left antler) of SAY (spike-antlered as yearlings) and FAY (fork-antlered as yearlings) white-tailed bucks at 2.5 years of age in the Kerr Wildlife Management Area deer herd, Kerr County, Texas.

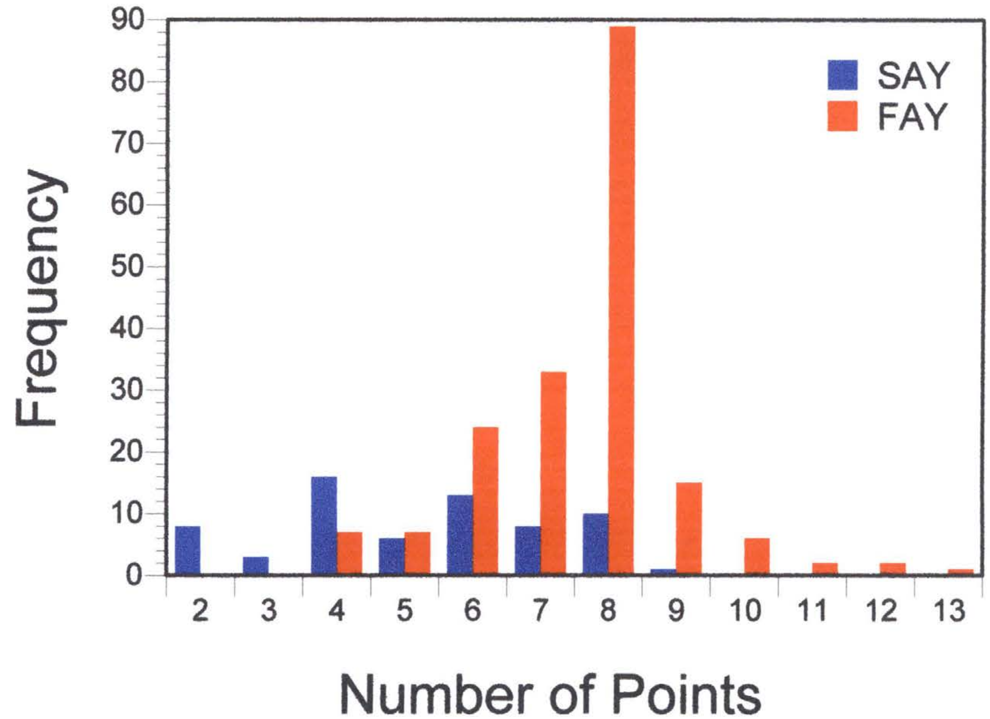

Figure 5. Distribution of the number of total points (typical and atypical) for SAY (spike-antlered as yearlings; N = 65) and FAY (fork-antlered as yearlings; N = 187) white-tailed bucks at 2.5 years of age in the Kerr Wildlife Management Area deer herd, Kerr County, Texas.

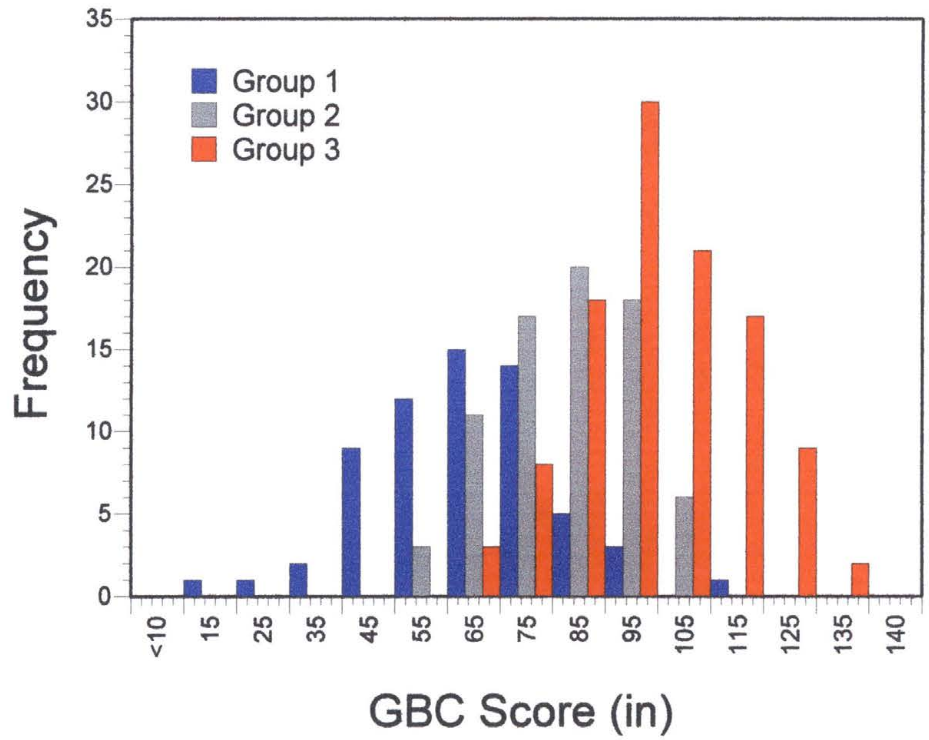

Figure 6. Distribution of gross Boone and Crockett (GBC) scores for Group 1 (spike-antlered as yearlings; N = 63), Group 2 (3-5 points as yearlings; N = 75), and Group 3 ($\geq$ 6 points as yearlings; N = 108) white-tailed bucks at 2.5 years of age in the Kerr Wildlife Management Area, Kerr County, Texas.

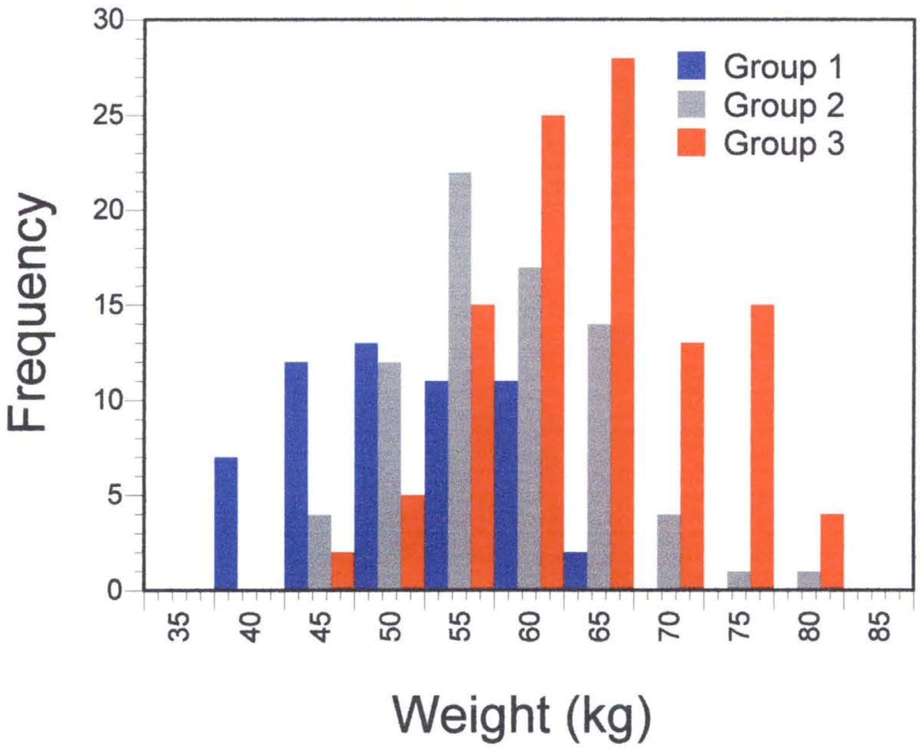

Figure 7. Distribution of live body weights of Group 1 (spike-antlered as yearlings; N = 56), Group 2 (3-5 points as yearlings; N = 75), and Group 3 ($\geq$ 6 points as yearlings; N = 107) white-tailed bucks at 2.5 years of age in the Kerr Wildlife Management Area deer herd, Kerr County, Texas.

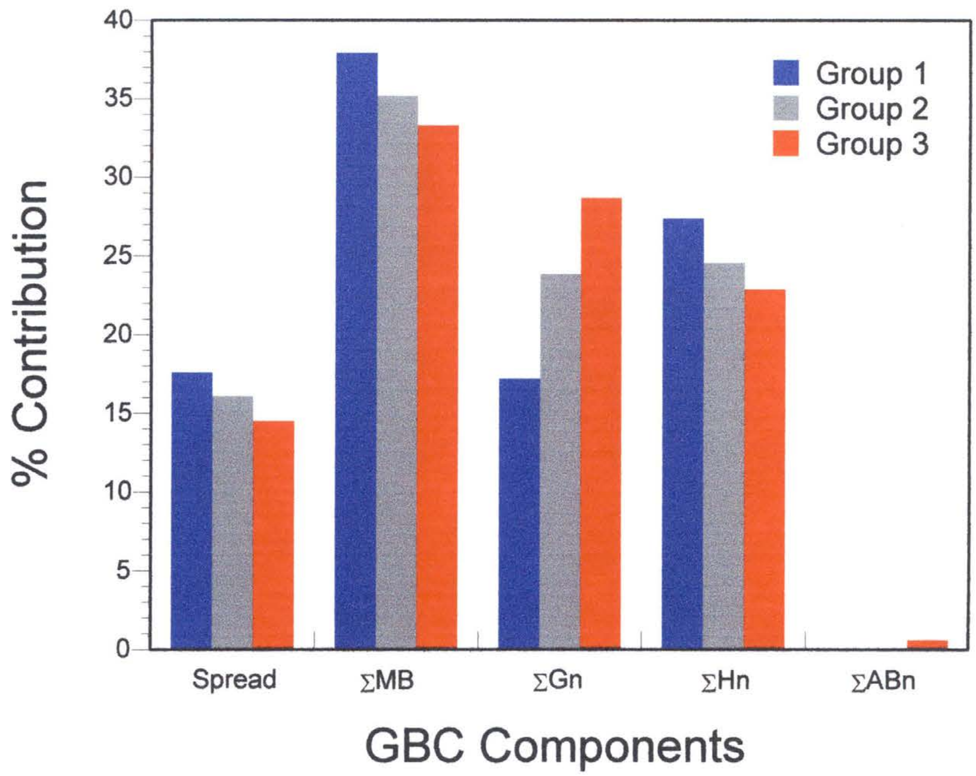

Figure 8. Percent compositions of GBC components (Spread = maximum inside spread between right and left antlers; ΣMB = combined length of right and left main beams; ΣG_n = combined length of all typical tines on right and left antler; ΣH_n = combined circumference of the four measurement positions of both right and left antler; ΣAB_n = combined length of all abnormal (atypical) points on right and left antler) of Group 1 (spike-antlered as yearlings), Group 2 (3-5 points as yearlings), and Group 3 (≥ 6 points as yearlings) white-tailed bucks at 2.5 years of age in the Kerr Wildlife Management Area deer herd, Kerr County, Texas.

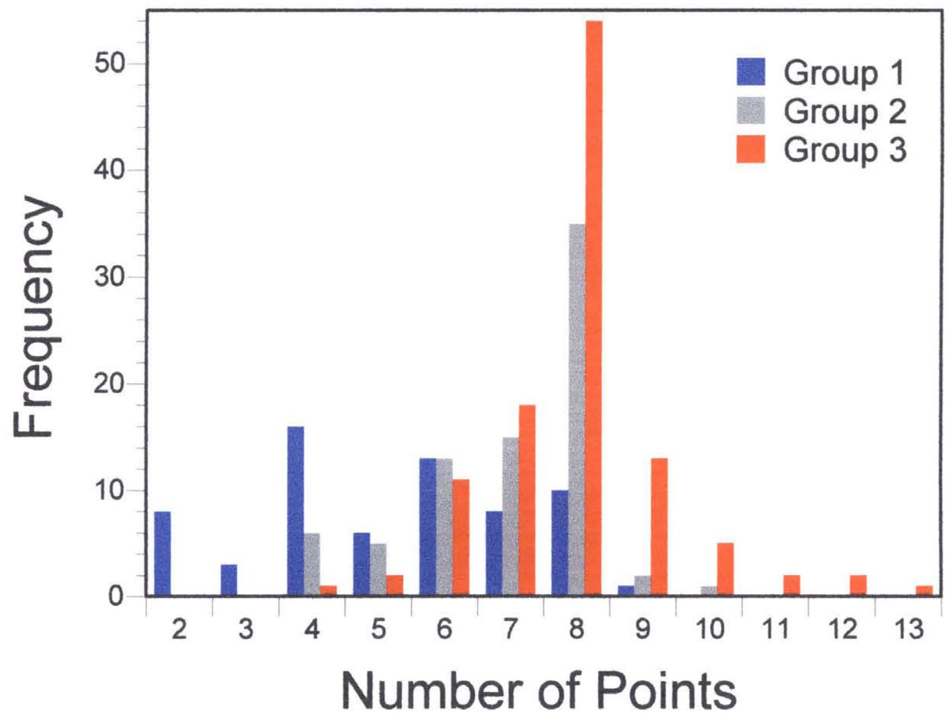

Figure 9. Distribution of the total number of points (typical and atypical) for Group 1 (spike-antlered as yearlings; N = 65), Group 2 (3-5 points as yearlings; N = 77), and Group 3 ($\geq$ 6 points as yearlings; N = 110) white-tailed bucks at 2.5 years of age in the Kerr Wildlife Management Area deer herd, Kerr County, Texas.

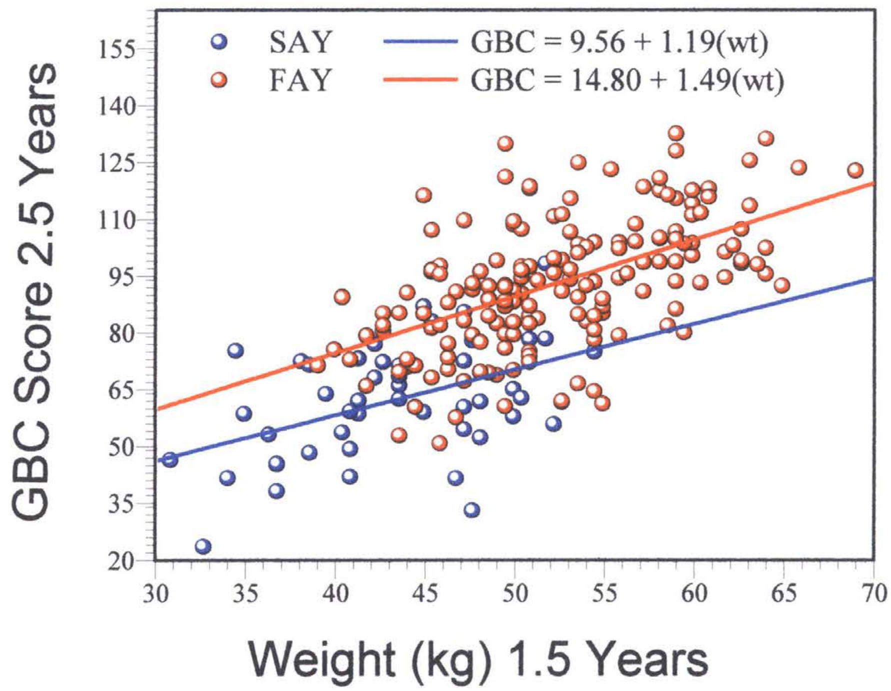

Figure 10. Regression of GBC scores of bucks at 2.5 years of age and weight at 1.5 years of age for spike-antlered (SAY; N = 49; R^2 = 0.17) and fork-antlered (FAY; N = 167; R^2 = 0.30) white-tailed bucks at 2.5 years of age in the Kerr Wildlife Management Area deer herd, Kerr County, Texas.

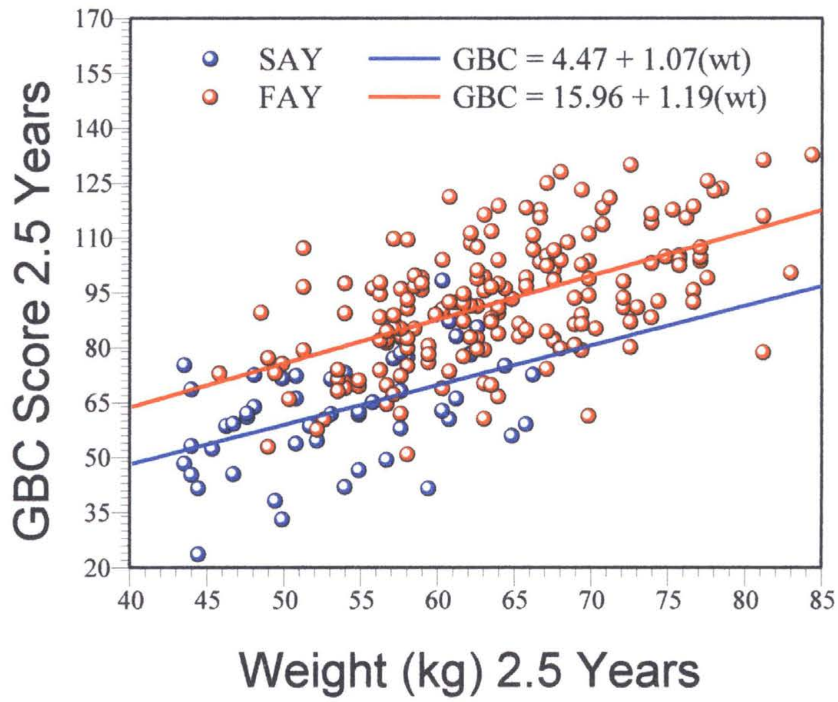

Figure 11. Regression of GBC scores of bucks at 2.5 years of age on weight at 2.5 years of age for spike-antlered (SAY; N = 53; R^2 = 0.19) and fork-antlered (FAY; N = 178; R^2 = 0.32) white-tailed bucks at 2.5 years of age in the Kerr Wildlife Management Area deer herd, Kerr County, Texas.

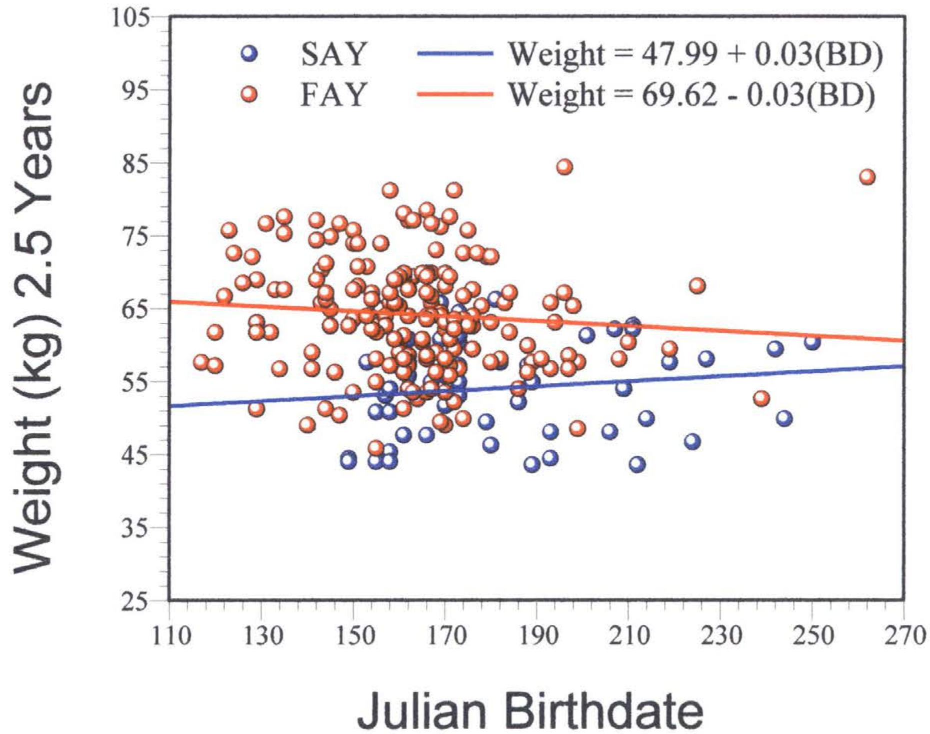

Figure 12. Regression of weight (kg) for bucks at 2.5 years of age and Julian birthdate for spike-antlered (SAY; N = 53; $R^2 = 0.02$) and fork-antlered (FAY; N = 178; $R^2 = 0.01$) white-tailed bucks at 2.5 years of age in the Kerr Wildlife Management Area deer herd, Kerr County, Texas.

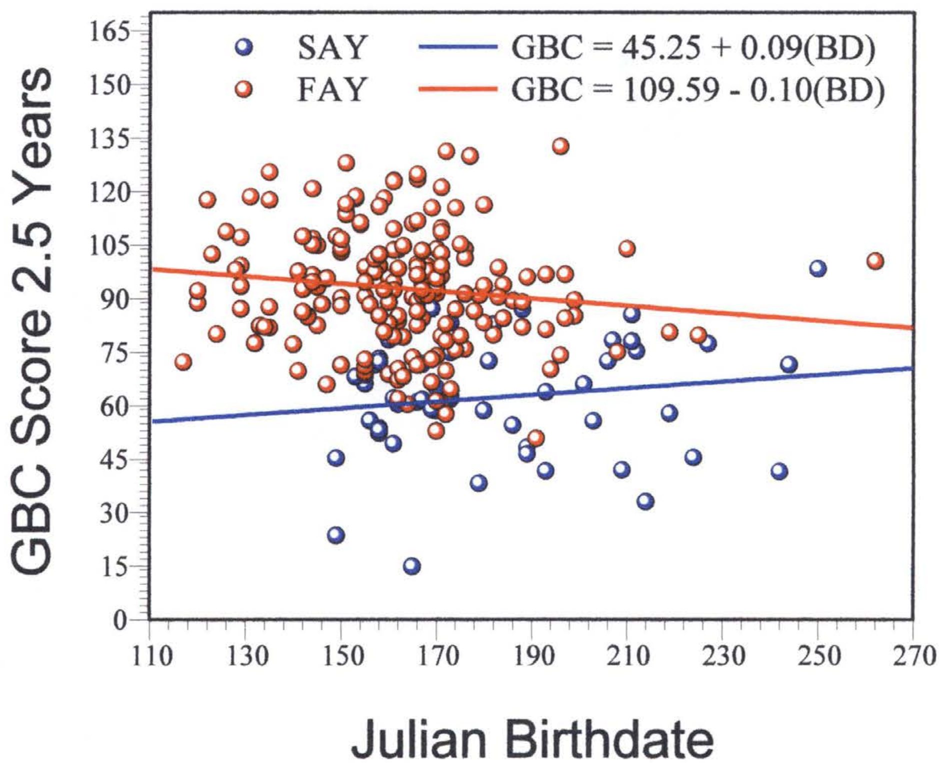

Figure 13. Regression of GBC scores of bucks at 2.5 years of age and Julian birthdate for spike-antlered (SAY; N = 54; $R^2 = 0.02$) and fork-antlered (FAY; N = 179; $R^2 = 0.02$) white-tailed bucks at 2.5 years of age in the Kerr Wildlife Management Area deer herd, Kerr County, Texas.

VITA

Ronald William Kirchhof II was born in San Antonio, Texas, on February 14, 1974, the son of Ronald William Kirchhof and Lynda Gayle Kirchhof. After completing his work at James Madison High School, San Antonio, Texas, in 1992, he entered Southwest Texas State University in San Marcos, Texas. He received his Bachelor of Arts in Biology from Southwest Texas State University in December, 1996. In January, 1997, he entered the Graduate School of Southwest Texas State University to pursue a Master of Science in Wildlife Biology. During his years as a graduate student, Ronald instructed Zoology labs for the Biology Department, and worked on three Texas Parks and Wildlife Management Areas during the summer of 1998, establishing baseline survey sites for birds, vegetation, small mammals, amphibians, and reptiles.

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