Effects of Genetics and Nutrition On Antler Development and Body Size Of White-tailed Deer

by
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Foreword

The harvest of male white-tailed deer having only 2 "points", also known as "spike bucks", has been a controversial subject among landowners, hunters, and biologists over the years. The role of nutrition on body size and antler development had been previously investigated by many researchers; however, the role of genetics had not been investigated. In 1973, the Texas Parks and Wildlife Department initiated research to investigate the roles of these 2 aspects on body size and antler development in white-tailed deer. Dr. John D. Williams provided the data base, statistical analysis, and data interpretation through an interagency agreement with the Texas A & M University Agricultural Experiment Station. This project was funded under the Federal Aid in Wildlife Restoration Act, a sportsmen funded program, which apportions revenues collected as manufacturers' excise taxes on sporting arms, pistols, ammunition, and archery equipment to the states and territories for the conservation and management of wild birds and mammals.

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ABSTRACT

In 1973, an experiment to determine the relationship between antler development, nutrition and genetics was begun by the Texas Parks and Wildlife Department in the research facilities at the Kerr Wildlife Management Area, Hunt, Texas. This research covers a period from 1973-1985, during which body weights and antler measurements (main beam spread and lengths, basal circumference, total antler points, and weight) were collected from 150 different male white-tailed deer. One hundred thirty-eight of these deer were produced by single male matings on the Kerr Wildlife Management Area during the period 1974-1981. Management was maintained as constant as possible and except for the nutrition portion, all deer were fed a 16% protein diet *ad libitum*. Twelve sires and 66 dams were used and 505 different sets of antlers were measured (150 at 1.5, 115 at 2.5, 90 at 3.5, 79 at 4.5, 54 at 5.5 and 17 at 6.5 or more years of age). Results indicate that (1) body weight and antler characteristics respond in direct proportions to the quality of their diet, (2) antler characteristics and body weight are phenotypic characters that are influenced both by genetics and nutrition, (3) yearling spike-antlered deer are inferior to fork-antlered yearlings with regard to body weight and antler characteristics and will remain so in succeeding years, (4) most deer which are spike-antlered as yearlings will not be spike-antlered in later years, but will continue to be inferior to their fork-antlered cohorts, and (5) body weight and antler characteristics appear to be highly heritable characters. We conclude from these results that spike-antlered white-tailed deer should not receive differential protection.

INTRODUCTION

In the 1960's and 1970's the Texas Parks and Wildlife Department received substantial criticism from landowners and hunters concerning the harvest of spike bucks. Opponents of spike buck harvest maintained that spike bucks must be protected to ensure adequate numbers of bucks in future harvests. While proponents of spike buck harvest contended that these deer are inferior animals and should be removed from the herd or receive no differential protection.

Other studies have been concerned with the relationship between nutrition and the formation of spike antlers with little or no emphasis on genetics. The influence of genetics on antler formation had not been investigated. This study attempts to evaluate nutrition and genetics as contributing factors to antler formation. These penned deer studies were conducted on the Kerr Wildlife Management Area located 13 miles west of Hunt, Texas in a 16-acre research facility consisting of 6 2.3-acre pens, 3 4-acre pens and 24 small individual pens (Fig 1). All deer involved in these studies were fed a commercial pelleted ration and provided free-choice water. The original deer were native Texas white-tailed deer which were obtained from various locations in the State. No additional deer were added after the fall of 1974 and the herd was maintained as a "closed" herd.

This study was divided into 3 phases, 2 nutritional and 1 genetic, with the following objectives:

1. To determine factors which contribute to antler formation in the white-tailed deer.
2. To determine the effect of nutrition level on antler formation and body weight.
3. To determine if deer that were spike-antlered at 1.5 years have the same potential for antler development and body weight in later years as deer that were fork-antlered at 1.5 years.
4. To estimate the influence of genetics on antler characteristics.

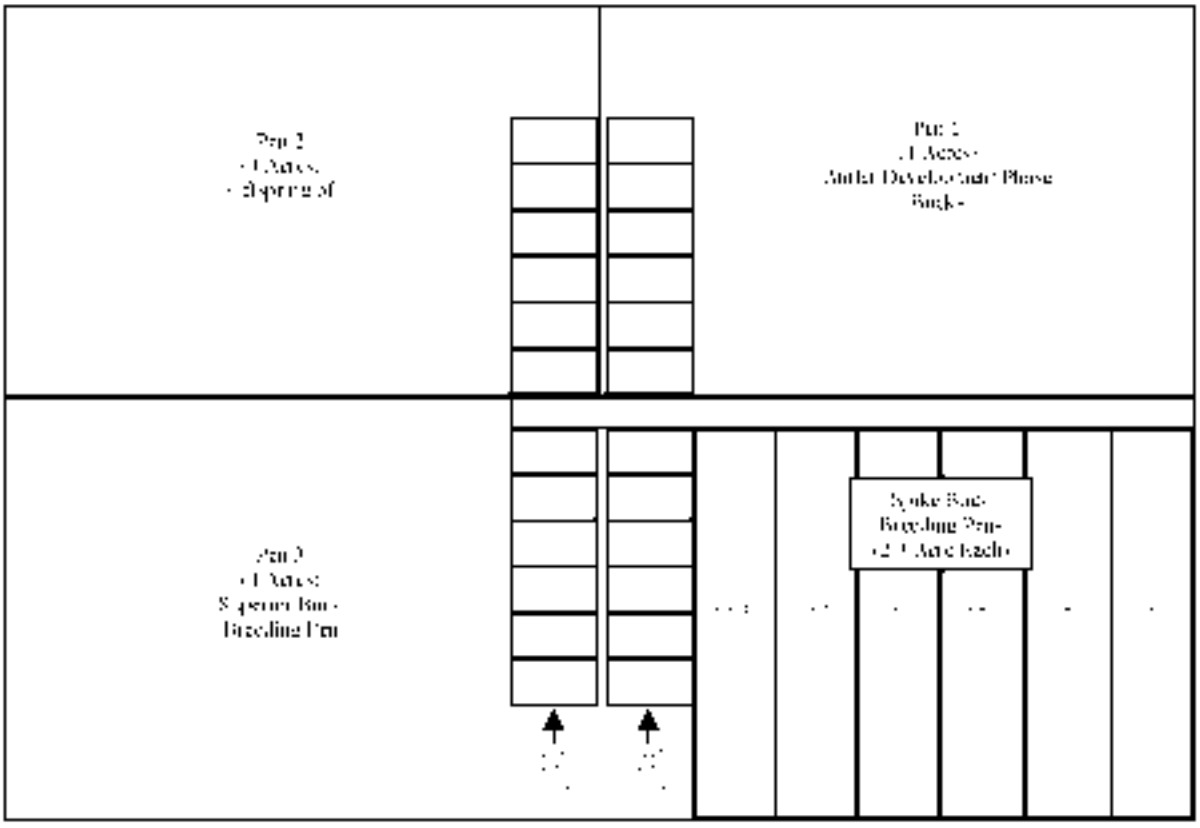

Figure 1. Diagram of the research pens used in this study.

NUTRITION PHASE I

Male white-tailed deer fawns were obtained in the summer of 1974 and hand reared on a ration of condensed milk diluted with 50% water. A pelleted 16% protein ration was made available to the fawns at approximately 2 months of age. At approximately 6 months of age, deer were randomly placed into individual 10' x 15' chain link pens and separated into 4 different groups. Deer were fed daily and all deer received the same total amount of feed throughout the study with only the protein level varying (16% vs. 8%) between groups.

The high protein groups of deer were to receive a 16% protein ration while the low protein groups were to receive an 8% protein ration. Feed problems were encountered with the low protein feed during the first year of the study. A feed analysis revealed that the low protein feed was 10.50% protein instead of the reported 8% level. This problem was corrected after the deer had grown their first set of antlers. Throughout the remaining portion of the study (2.5-, 3.5-, and 4.5-year old sets of antlers) the low protein groups of bucks received the proper 8% protein diet. No problems were encountered with the high protein ration.

Five deer were maintained on a high protein (16%) ration during all 4 years of the study as a control group (HHHH group). A group of 4 deer were maintained on the low protein ration during all 4 years of the study (LLLL group); however, only 2 deer remained in this group at the end of the fourth year.

A group of 4 deer were fed the high protein diet during their first year's antler development, but were switched to the low protein ration prior to their second year's antler growth. In the third year, they were switched back to the high protein diet and in the fourth year they were switched back to the low protein diet (HLHL group).

A group of 4 deer were initially started on the low protein ration. This group was switched to the high protein ration for their second year's antler development. In the third year, only 3 deer remained and were switched back to the low protein ration. In the fourth year, this group was switched back to the high protein diet (LHLH group). Diets for all deer in the HLHL and LHLH groups were switched in February (prior to antler development) of each year.

The total number of points (> 25 mm in length), basal circumference, maximum inside spread of the main beams, main beam lengths, total antler weight, body weight, and a photograph of each deer were recorded annually.

Crude protein analysis were run on all feed shipments after the first year of the study to insure acceptable protein levels. All high protein shipments tested in excess of the 16% protein level and the low protein feed tested at or slightly below the 8% level. Ingredients of the high and low protein feed are shown in Table 1.

Individual yearly body weights and antler measurements for all deer involved in the nutrition phase of the study are shown in Tables 2-5 and Figs. 2-7.

Table 1. High (16%) and low (8%) protein diets used in Kerr Wildlife Management Area antler development studies.

Ingredients	Low Protein (8%)	High Protein (16%) [a]
Rice Hulls	550 lbs	--------
Peanut Hulls	--------	400 lbs
Ground Oats	250 lbs	--------
Dehydrated Alfalfa Meal	100 lbs	100 lbs
Corn Meal	790 lbs	400 lbs
Ground Milo	--------	440 lbs
Cottonseed Meal	--------	300 lbs
Soybean Meal (44%)	--------	200 lbs
Molasses	100 lbs	--------
Masonex	50 lbs	100 lbs
Bentonite	100 lbs	--------
Vitamin/Trace Mineral Premix	10 lbs	10 lbs
Trace Minerals	50 lbs	50 lbs
Aeromycin	40 g	40 g
	2,000 lbs	2,000 lbs

[a] Ration modified from Verme and Ullrey (1972).

Body Weights (Tables 2-5, Fig. 7)

Live body weights were not collected during the first year (1975) of study but were collected for the remaining 3 years. Heaviest body weights were attained from the HHHH group while the LLLL group exhibited the lightest body weights. The body weights of the 2 groups whose diets were switched yearly were intermediate between constant high (HHHH) and the constant low (LLLL) protein groups. Yearly average body weights of the switched groups showed a direct relationship to their diets, with the high protein groups exhibiting heavier body weights than the low protein group within that same year.

Antler Characteristics (Tables 2-5, Figs. 2-6)

There were no noticeable differences between the groups of deer at 1.5 years of age. This probably attributed to the fact that the low protein groups of deer were receiving a 10.5% protein diet instead of the required 8% level.

The LHLH group exhibited the greatest antler development in all categories at 2.5 years of age while the LLLL group exhibited the smallest measurements. The HHHH group exhibited the second largest antler measurements in all categories except inside main beam spread, where the HLHL group surpassed them. The HLHL group exhibited the third largest antler measurements in the remaining categories.

The HLHL group exhibited superior measurements in main beam spread, main beam length and antler weight for the 3.5-year old age class. The LLLL group had the most number of points while the LHLH group had the largest basal circumference.

The 2 remaining deer in the LHLH group exhibited superior antler development in all antler characteristics while the 2 remaining deer in the LLLL group exhibited the poorest antler development.

During the last 3 years of the study, the group of deer that were on the continuous high protein ration (HHHH) was superior to the continuous low protein group (LLLL) in all morphological characteristics. The 2 groups whose diets were alternately switched from year to year exhibited intermediate morphological characteristics with individual deer performance depending upon the yearly diet. Deer in these groups responded to the quality of their diets, with some deer while on the high protein ration exceeding deer in the HHHH group. This variability among deer would indicate some genetic influence on the ability to exhibit phenotypic characteristics. If a deer

receives a poor nutritional diet during the first few years of life and if the nutritional quality is later improved, antler development will respond accordingly. Likewise, if the quality of the ration is lowered, antler quality will also decrease. If maximum potential body weights are to be achieved, a high level of nutrition is needed throughout the deer's life. The HHHH group achieved the largest body weights when compared to the switched groups and the LLLL groups (Table 6). Deer on fluctuating diets probably will not achieve their maximum body weight potential because skeletal development may be retarded during periods of poor nutrition. Antler development, however, will respond according to the quality of the diet.

Table 2. Individual measurements for 5 wh tetailed deer fed a 16% protein diet for 4 years (HHHH++)

Id	Protein %	Age (years)	Main beam length (mm)		Basal circumference (mm)		Total points	Antler weight (g)	Main beam spread (mm)	Body weight (lbs)
			right	left	right	left				
92-97	16	1.5	176	170	61	60	6	150	240	---
	16	2.5	315	310	67	65	6	313	342	148
	16	3.5	453	460	92	89	8	642	372	177
	16	4.5	502	514	91	91	8	719	368	188
91-54	16	1.5	170	170	60	59	2	93	288	
	16	2.5	338	315	68	72	6	330	325	135
	16	3.5	413	450	93	92	8	609	32	160
	16	4.5	447	435	95	95	8	839	335	164
84-42	16	1.5	260	264	80	70	5	225	297	
	16	2.5	340	351	74	78	6	459	302	169
	16	3.5	425	445	95	97	6	755	375	184
	16	4.5	430	458	97	96	6	801	392	184
66-45	16	1.5	196	248	68	81	8	270	210	---
	16	2.5	370	366	76	77	8	435	320	155
	16	3.5	448	440	91	91	8	735	390	168
	16	4.5	370	375	88	88	6	521	330	149
61-45	16	1.5	200	184	68	66	5	141	165	
	16	2.5	363	389	91	87	8	561	269	155
	16	3.5	380	413	95	92	7	761	290	185
	16	4.5	433	425	96	98	8	963	330	169

Table 3. Individual measurements for 4 white-tailed deer fed an 8% protein diet for 4 years (LLLL)

Id	Protein %	Age (years)	Main beam length (mm)		Basal circumference (mm)		Total points	Antler weight (g)	Main beam spread (mm)	Body weight (lbs)
			right	left	right	left				
67-15	16	1.5	204	185	79	72	6	162	208	
	8	2.5	230	234	77	80	4	175	242	104
	16	3.5	403	405	84	85	8	600	355	150
	8	4.5	257	280	70	72	8	269	310	125
38-32	16	1.5	173	250	75	85	6	207	252	---
	8	2.5	418	417	78	80	8	482	472	113
	8	3.5	425	387	95	91	10	620	536	125
	8	4.5	417	414	84	82	7	539	472	116
98-44	16	1.5	216	190	71	82	6	183	269	---
	8	2.5	270	256	75	70	6	240	258	117
98-42	16	1.5	142	129	62	58	4	56	160	---
	8	2.5	223	226	64	61	5	168	242	120

Table 4. Individual measurements for 4 white-tailed deer fed a 16% and 8% protein diet alternately for 4 years (LLLL)

Id	Protein %	Age (years)	Main beam length (mm)		Basal circumference (mm)		Total points	Antler weight (g)	Main beam spread (mm)	Body weight (lbs)
			right	left	right	left				
70-51	16	1.5	230	245	73	86	2	131	328	
	8	2.5	330	342	73	72	7	447	383	127
	16	3.5	454	450	88	91	8	801	540	144
	8	4.5	500	511	90	87	10	812	445	138
94-35	16	1.5	238	253	85	87	6	187	230	---
	8	2.5	351	340	74	75	6	328	304	110
	16	3.5	448	425	94	94	8	651	457	161
	8	4.5	406	414	92	92	8	674	582	156
57-51	16	1.5	180	230	67	80	4	153	270	---
	8	2.5	317	266	80	78	7	188	277	113
	16	3.5	445	435	115	91	8	847	551	161
	8	4.5	389	344	88	92	8	818	420	143
82-14	16	1.5	---	---	---	---	---	---	---	---
	8	2.5	258	311	64	68	5	205	302	105
	16	3.5	430	428	90	86	8	691	510	134
	8	4.5	389	382	95	87	8	498	480	132

Table 5. Individual measurements for 4 white-tailed deer fed an 8% and 16% protein diet alternately for 4 years (1991–1994).

Id	Protein %	Age (years)	Main beam length (mm)		Basal circumference (mm)		Total points	Antler weight (g)	Main beam spread (mm)	Body weight (kg)
			right	left	right	left				
91-02	16	1.5	133	201	68	91	5	159	245	—
	8	2.5	349	352	97	93	7	469	407	128
	16	3.5	891	431	107	106	7	621	423	121
	8	4.5	490	428	105	105	6	719	408	137
93-04	16	1.5	252	267	73	77	5	234	327	—
	8	2.5	417	424	88	87	8	578	585	127
	16	3.5	479	440	107	105	6	882	890	139
	8	4.5	490	487	124	115	10	1050	445	157
92-39	16	1.5	126	149	62	69	2	75	—	
	8	2.5	396	351	78	76	8	465	370	125
	16	3.5	415	424	88	87	8	621	827	162
85-44	16	1.5	236	217	67	81	6	158	302	—
	8	2.5	332	334	85	85	7	433	429	142

Table 6. Average antler measurements and body weight for white-tailed deer fed a high (16% or less (8%) protein diet continuously or alternately for 4 years.

Sample Size	Protein %	Age (years)	Main beam length (mm)	Basal circumference (mm)	Total points	Antler weight (g)	Main beam spread (mm)	Body weight (kg)
5	16	1.5	236.00	68.40	5.20	159.00	227.00	—
5	16	2.5	421.60	88.20	10.80	428.20	328.80	151.20
5	16	3.5	435.00	93.60	8.20	717.20	442.00	134.40
5	16	4.5	422.60	93.20	8.40	719.00	351.40	164.60
4	16	1.5	136.38	72.50	5.50	144.25	249.75	—
4	8	2.5	259.38	67.63	5.75	233.25	268.75	115.00
2	8	3.5	405.00	88.50	9.00	650.00	353.50	139.50
2	8	4.5	200.75	71.25	7.50	211.00	311.00	122.50
3	16	1.5	333.17	98.67	4.00	197.00	278.00	
4	8	2.5	325.63	71.75	6.25	333.75	339.00	117.75
4	16	3.5	437.75	93.88	8.00	732.50	442.00	150.00
4	8	4.5	413.00	88.75	8.75	637.25	413.00	142.25
4	16	1.5	205.13	74.13	4.50	151.00	296.00	
4	16	2.5	369.88	85.13	7.50	484.00	382.25	123.67
3	8	3.5	431.00	100.00	8.00	708.67	383.00	145.67
2	16	4.5	462.50	112.75	9.50	889.00	426.50	144.00

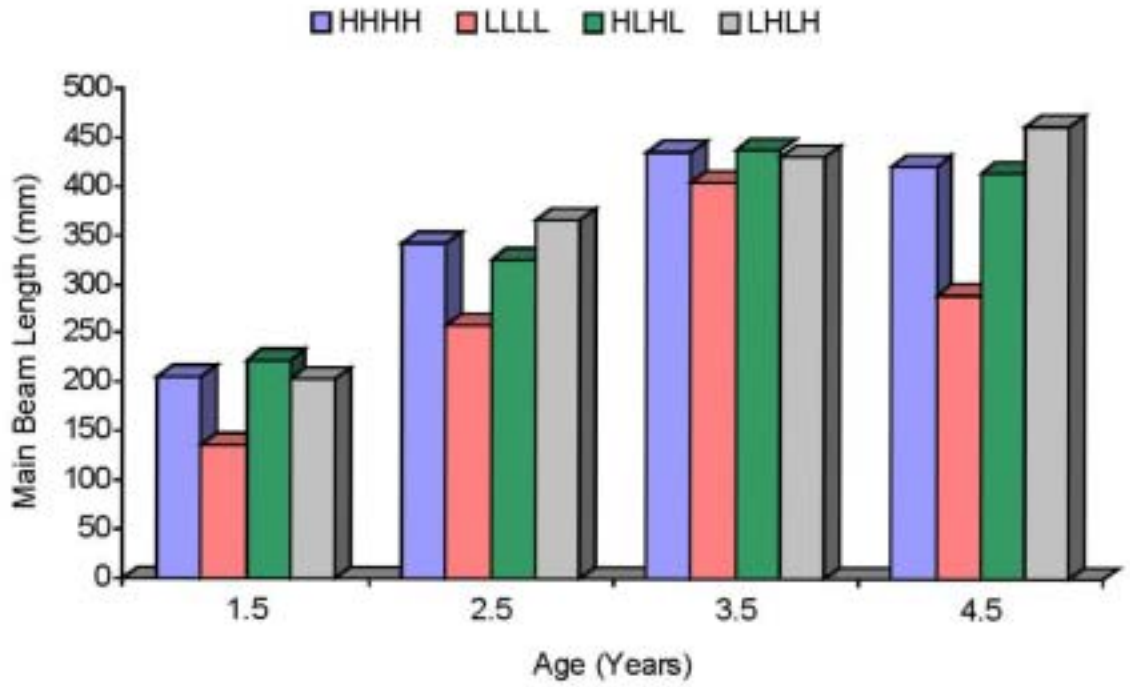

Figure 2. Average main beam length for white-tailed deer fed a high (H) or low (L) protein diet continuously or alternately for 4 years.

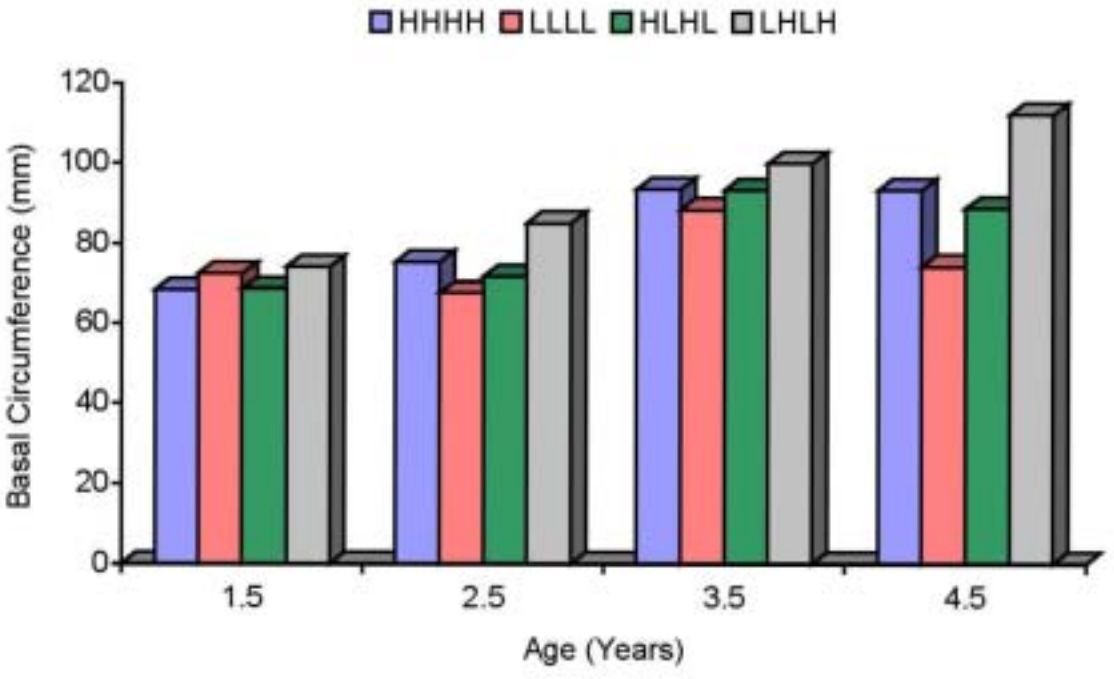

Figure 3. Average basal circumference for white-tailed deer fed a high (H) or low (L) protein diet continuously or alternately for 4 years.

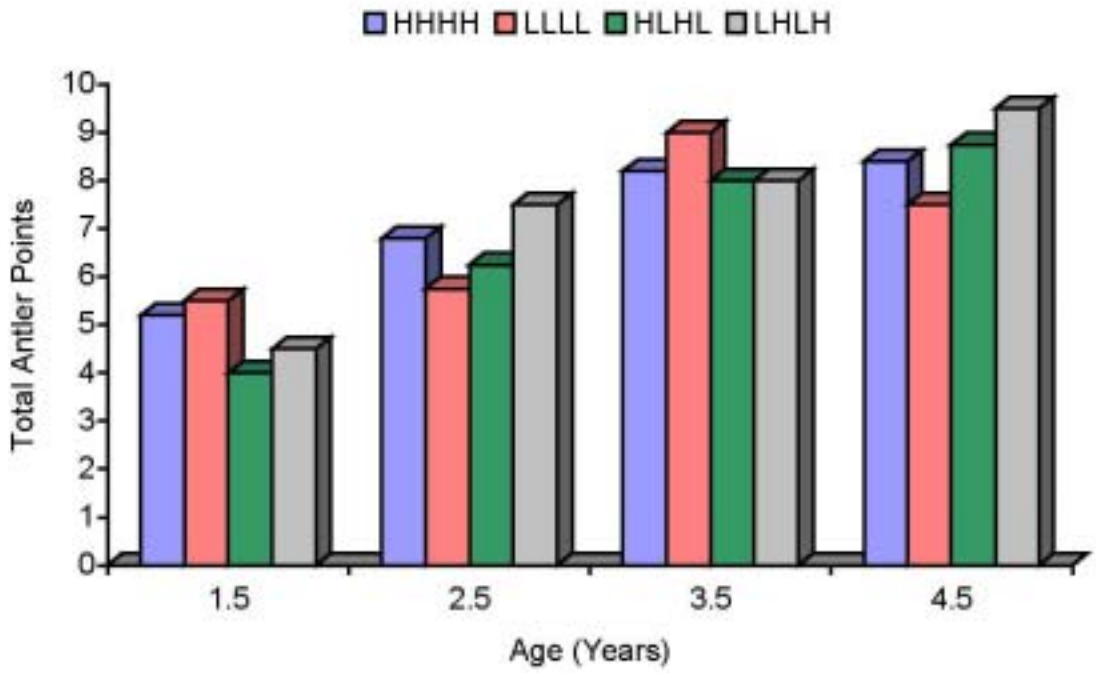

Figure 4. Average total antler points for white-tailed deer fed a high (H) or low (L) protein diet continuously or alternately for 4 years.

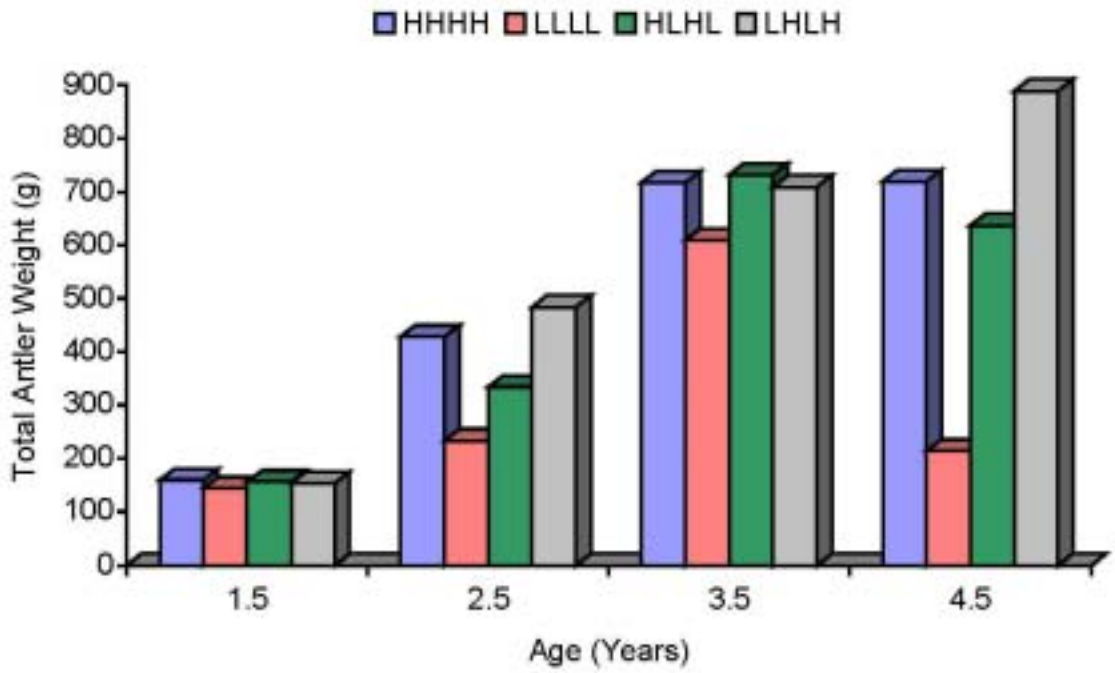

Figure 5. Average total antler weight for white-tailed deer fed a high (H) or low (L) protein diet continuously or alternately for 4 years.

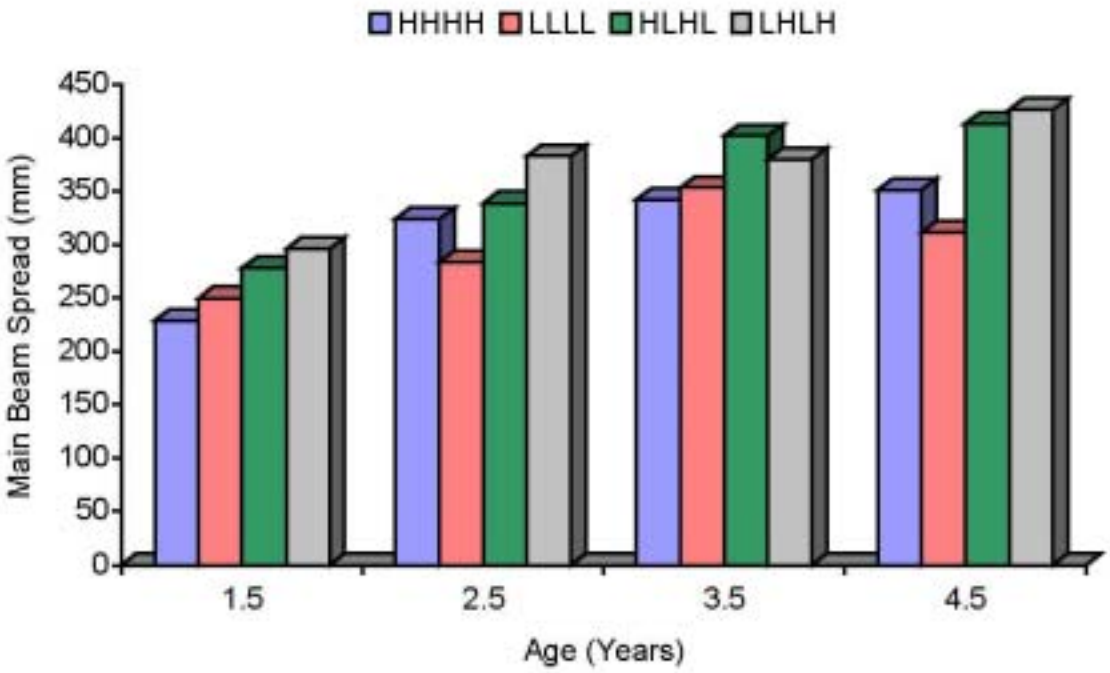

Figure 6. Average main beam spread for white-tailed deer fed a high (H) or low (L) protein diet continuously or alternately for 4 years.

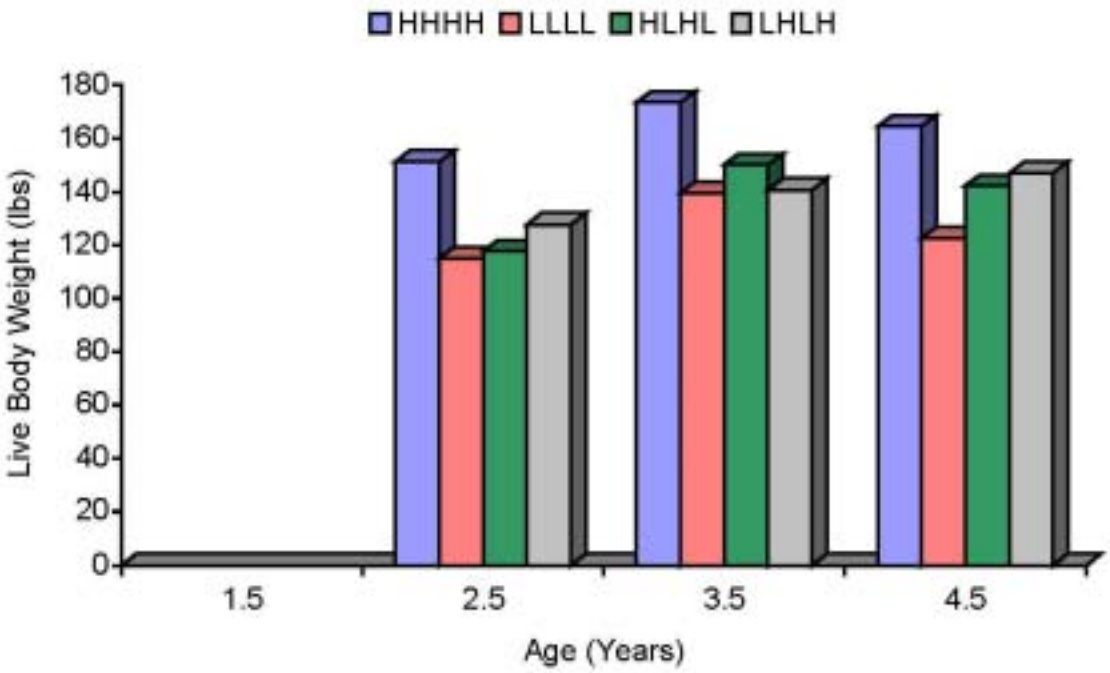

Figure 7. Average live body weight for white-tailed deer fed a high (H) or low (L) protein diet continuously or alternately for 4 years.

NUTRITION PHASE II

A group of 16 bucks born in 1973 were maintained on the 16% high protein diet (Table 1) *ad libitum* to demonstrate the long term effect of good nutrition on antler development and body size. Nine of these bucks were spike-antlered yearlings (1.5-years-old) and 7 were fork-antlered. Their yearling antler status, spike- or fork-antlered, was used for grouping in successive years. Antler development and body weights of the spike-antlered group versus the fork-antlered group were compared each year to determine if the spike-antlered group remained inferior to the fork-antlered group in later years.

All bucks were captured during the last 2 weeks of October and the first week of November each year. The total number of points (>25 mm in length), basal circumference, maximum inside spread of the main beams, main beam lengths, total antler weight, body weight (1.5 and 2.5 years were not recorded), and a photograph of each deer were recorded annually.

Throughout the 6-year study, the spike-antlered group was consistently smaller in body size and antler development than the fork-antlered group (Tables 7-9, Figs. 9-14). Antlers of the spike-antlered group generally averaged approximately half the weight of the fork-antlered group within each year. In all other measurements, the fork-antlered group also surpassed the spike-antlered group throughout the 6-year study. One particular buck in the spike-antlered group never produced more than 4 points.

These data do not support the old belief that spike bucks should be protected during the hunting season with the idea that they will be the good quality bucks in future years. Even though some spike bucks develop into quality animals, on the average they will not in later years equal deer that had forked antlers as yearlings (Fig. 8). Therefore, spike bucks should not receive differential protection during the hunting season.

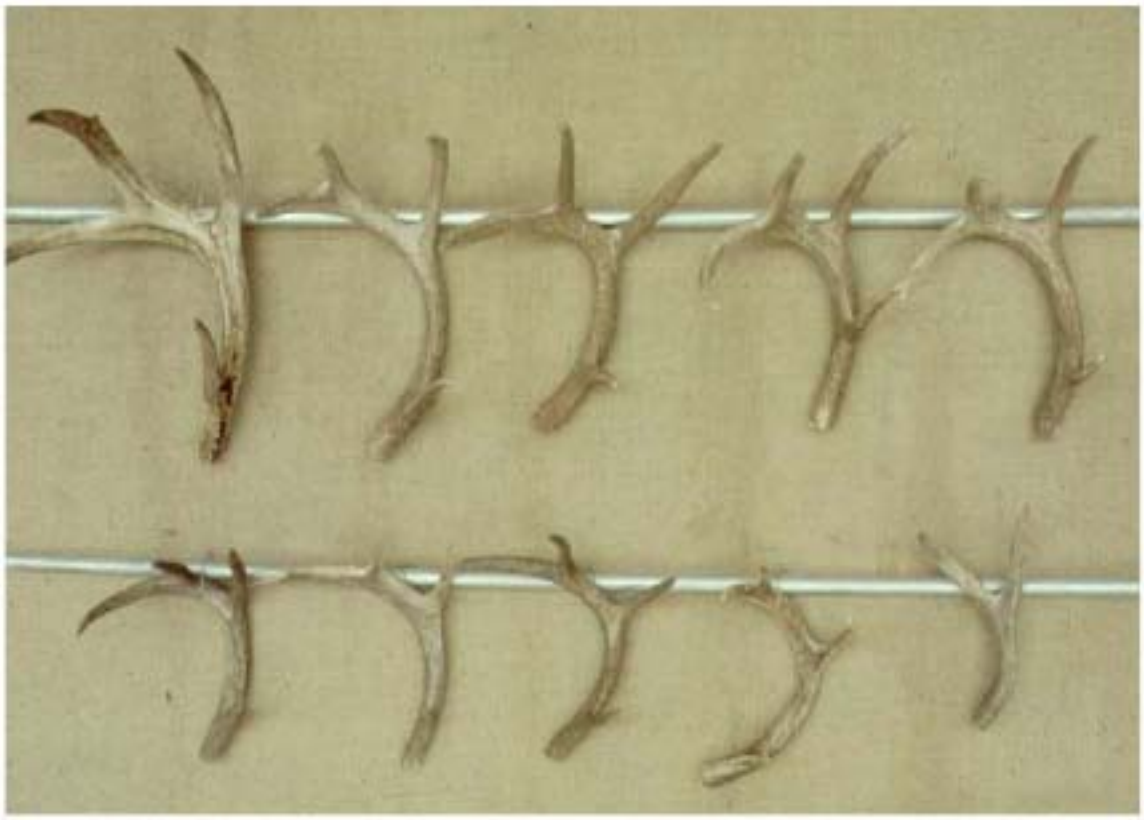

Figure 8. Antlers of 3.5-year-old bucks, all of which received a 16% protein ration *ad libitum*. The 5 antlers (above) are from bucks that were forked-antlered at 1.5 years of age. The 5 antlers (below) were from bucks that were spike-antlered at 1.5 years of age.

Table 7. Measurements for 9 white-tailed deer that were spike-antlered at 1.5 years of age

Id	Age (years)	Main beam length (mm) right	Main beam length (mm) left	Basal circumference (mm) right	Basal circumference (mm) left	Total points	Antler weight (g)	Main beam spread (mm)	Body weight (lbs)
65-88	1.5	[illegible]	151	45	[illegible]	2	52	---	---
	2.5	261	290	62	65	7	223	276	
	3.5	310	322	78	77	6	[illegible]	350	155
	4.5	[illegible]	318	8[illegible]	82	[illegible]	[illegible]	[illegible]	[illegible]
73-11	1.5	152	[illegible]	56	53	2	72	---	---
	2.5	242	[illegible]	[illegible]	71	[illegible]	212	275	---
	3.5	216	258	79	[illegible]	[illegible]	222	325	115
	4.5	[illegible]	330	88	84	9	371	[illegible]	[illegible]
	5.5	382	385	88	87	[illegible]	590	350	160
	6.5	328	358	88	83	[illegible]	512	350	161
00-70	1.5	---	---	---	---	2	---	---	---
	2.5	315	332	87	82	9	430	395	---
	3.5	[illegible]	355	86	87	8	800	377	170
	4.5	358	390	98	100	8	[illegible]	311	191
	5.5	375	396	117	115	10	[illegible]	352	174
73-20	1.5	82	81	52	45	2	30	---	---
	2.5	315	325	76	75	6	374	360	
	3.5	350	361	80	83	7	452	355	16[illegible]
	4.5	350	360	101	97	8	[illegible]	395	193
	5.5	370	385	101	101	7	802	410	189
	6.5	408	422	95	95		[illegible]	392	188
73-16	1.5	61	21	36	10	2	[illegible]		
	2.5	355	367	78	78	7	517	298	---
	3.5	310	310	80	80	8	552	385	
	4.5	360	356	[illegible]	91	9	698	398	169
	5.5	370	358	90	88	8	690	396	159
	6.5	295	312	96	91	9	717	417	165
73-23	1.5	100	111	42	42	2	29	---	---
	2.5	325	332	85	82	8	555	---	---
	3.5	425	420	97	91	8	733	356	175
	4.5	405	475	98	93	8	1011	366	191
	5.5	402	457	97	[illegible]	8	1003	345	177
00-10	1.5	[illegible]	159	42	52	2	58	---	---
	2.5	235	242	73	71	6	335	321	
	3.5	308	338	88	85	7	[illegible]	360	163
	4.5	322	[illegible]	101	108	8	[illegible]	395	185
5-61	1.5	51	52	36	35	2	[illegible]	---	---
	2.5	215	278	64	65	[illegible]	225	258	
	3.5	315	302	[illegible]	[illegible]	5	385	297	[illegible]
	4.5	310	325	90	87	6	321	300	140
	5.5	402	356	90	91	5	[illegible]	315	[illegible]
00-11	1.5	---	---	---	---	2	---	---	---
	2.5	365	319	82	88	10	622	353	
	3.5	360	415	103	104	9	918	407	[illegible]

Table 8. Measurements for 7 white-tailed deer that were fork-antlered at 1.5 years of age

Id	Age (years)	Main beam length (mm) right	Main beam length (mm) left	Basal circumference (mm) right	Basal circumference (mm) left	Total points	Antler weight (g)	Main beam spread (mm)	Body weight (lbs)
75-05	1.5	---	---	---	---	4	---	---	---
	2.5	470	455	89	93	11	1019	425	---
	3.5	552	550	109	107	10	1512	458	211
	4.5	620	610	116	115	10	1864	464	216
	5.5	625	620	130	118	11	2165	475	209
	6.5	577	571	123	114	13	2258	481	216
75-07	1.5	202	235	66	62	4	165	---	---
	2.5	352	383	87	89	8			
	3.5	---	---	---	---	---	---	---	177
	4.5								205
	5.5	515	540	112	94	6	927	392	182
	6.5	506	489	107	94	6	832	375	185
76-73	1.5	223	220	68	65	5	176	---	---
	2.5	435	429	85	82	8	644	338	---
	3.5	493	480	97	95	8	971	458	157
	4.5	535	500	115	111	10	1358	470	177
	5.5	525	556	107	110	9	1069	465	172
	6.5	507	517	105	107	8	1093	450	175
79-81	1.5	---	---	---	---	4	---	---	---
	2.5	385	425	87	89	7	628	372	
	3.5	510	515	100	97	8	1175	395	178
	4.5	[illegible]	525	111	112	8	1315	412	201
	5.5	600	575	112	105	9	1176	485	201
	6.5	542	551	116	104	8	1385	[illegible]	202
75-71	1.5	160	141	52	52	4	69		
	2.5	283	277	78	75	7	378	315	---
	3.5	386	386	87	85	8	570	355	170
	4.5	460	410	100	98	9	748	352	202
	5.5	475	433	101	105	9	722	340	182
	6.5	457	452	103	102	8	680	335	182
75-21	1.5	237	320	55	62	4	104	---	---
	2.5	392	388	85	86	8	531	427	---
	3.5	486	507	100	101	8	1156	441	164
	4.5	506	518	121	112	10	1191	455	182
97-07	1.5	231	212	58	65	6	136	---	---
	2.5	312	302	67	78	8	376	324	---
	3.5								131
	4.5	---	---	---	---	---	---	---	[illegible]

Table 9. Average antler measurements and body weights of bucks classified as spike- or fork-antlered at 1.5 years of age.

Group	Sample size	Age (years)	Main beam length (mm)	Basal circumference (mm)	Total points	Antler weight (g)	Main beam spread (mm)	Body weight (lbs)
Fork	7	2.5	377.0	84.4	8.1	595.2	366.0	---
Spike	9	2.5	297.3	75.1	6.8	389.0	297.1	---
Fork	7	3.5	418.0	98.1	8.4	1132.8	494.6	171.1
Spike	9	3.5	360.7	82.9	7.2	567.3	385.2	164.2
Fork	7	4.5	436.2	112.0	9.4	1361.8	538.0	193.6
Spike	8	4.5	369.0	95.0	7.4	694.5	421.1	174.0
Fork	5	5.5	430.8	109.2	8.8	1266.0	528.1	189.8
Spike	6	5.5	359.7	97.3	7.0	777.2	445.4	166.7
Fork	5	6.5	423.0	108.3	9.0	1249.2	508.9	191.6
Spike	3	6.5	386.3	92.7	6.7	676.3	387.0	171.7

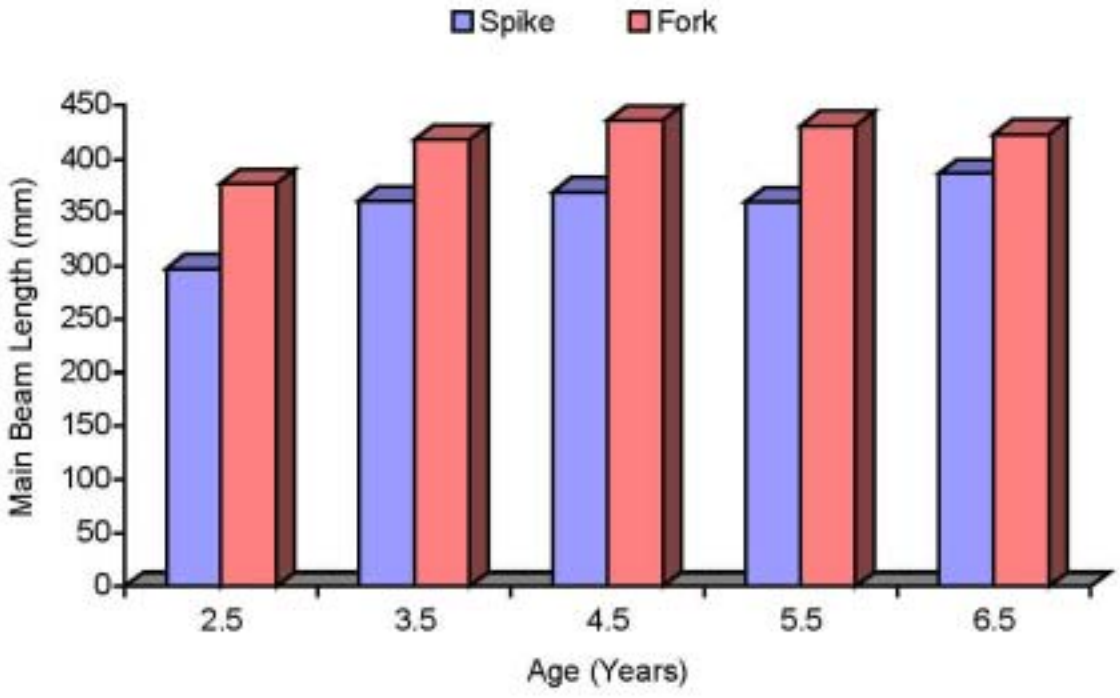

Figure 9. Average main beam length for white-tailed deer that were classified as spike- or fork-antlered at 1.5 years of age.

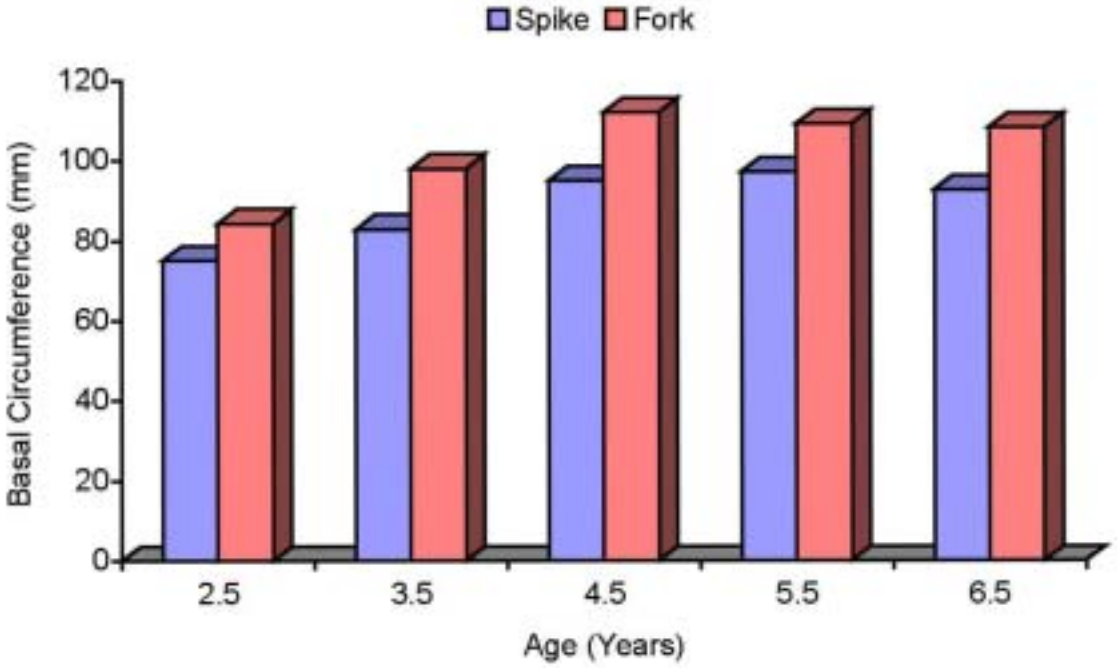

Figure 10. Average basal circumference for white-tailed deer that were classified as spike- or fork-antlered at 1.5 years of age.

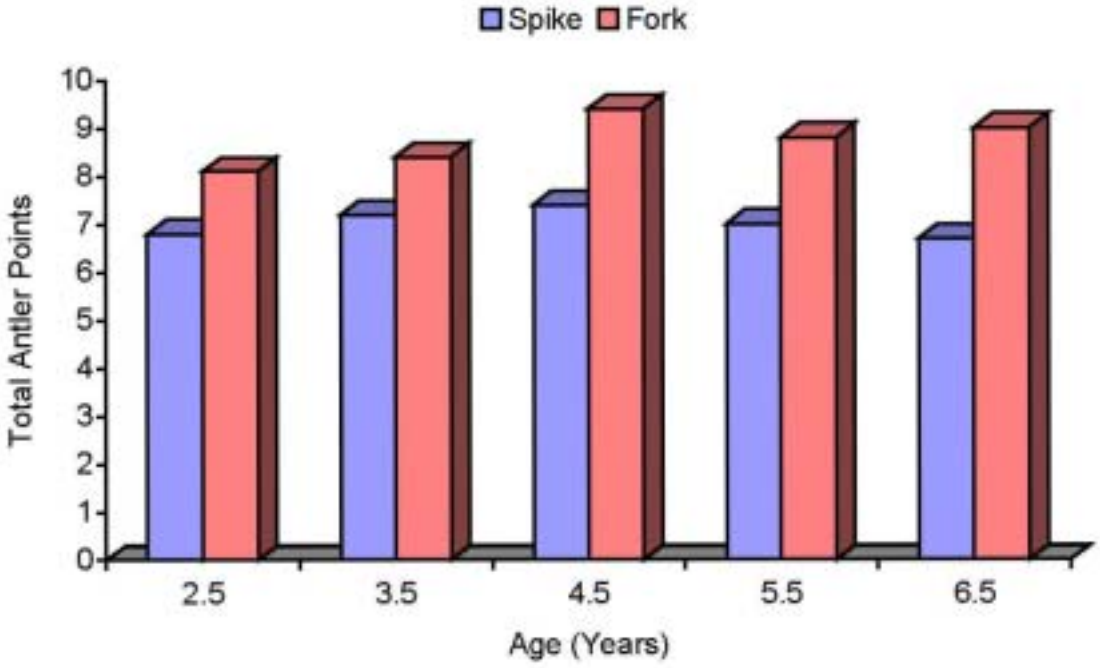

Figure 11. Average total antler points for white-tailed deer that were classified as spike- or fork-antlered at 1.5 years of age.

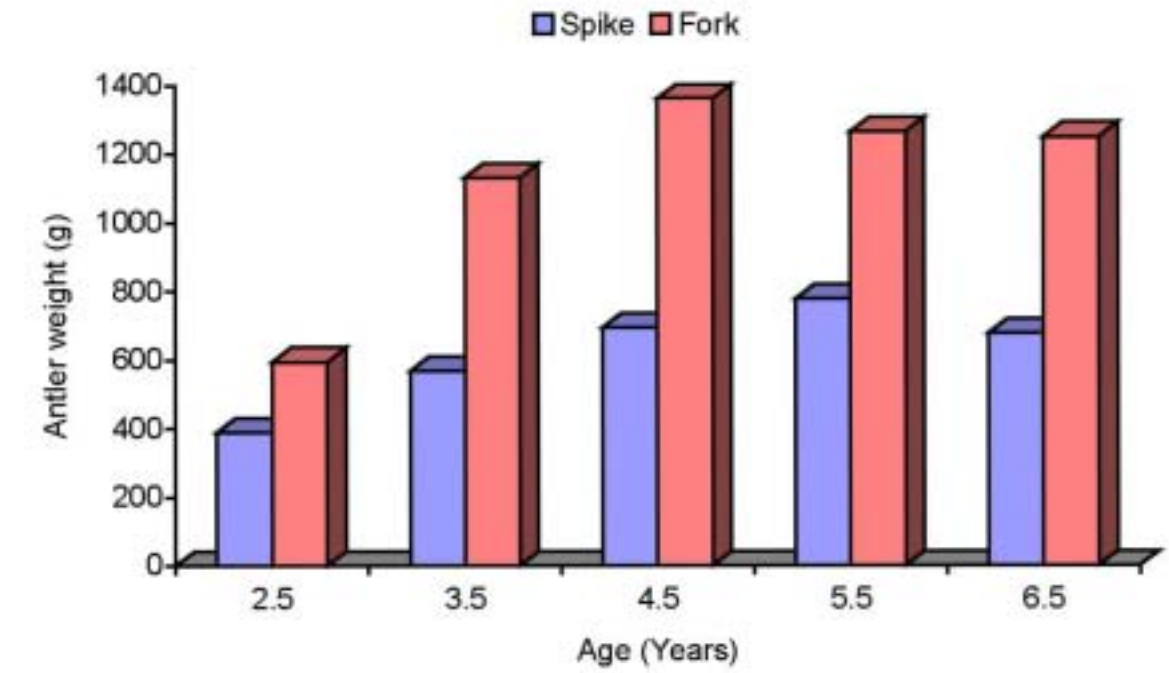

Figure 12. Average total antler weight for white-tailed deer that were classified as spike- or fork-antlered at 1.5 years of age.

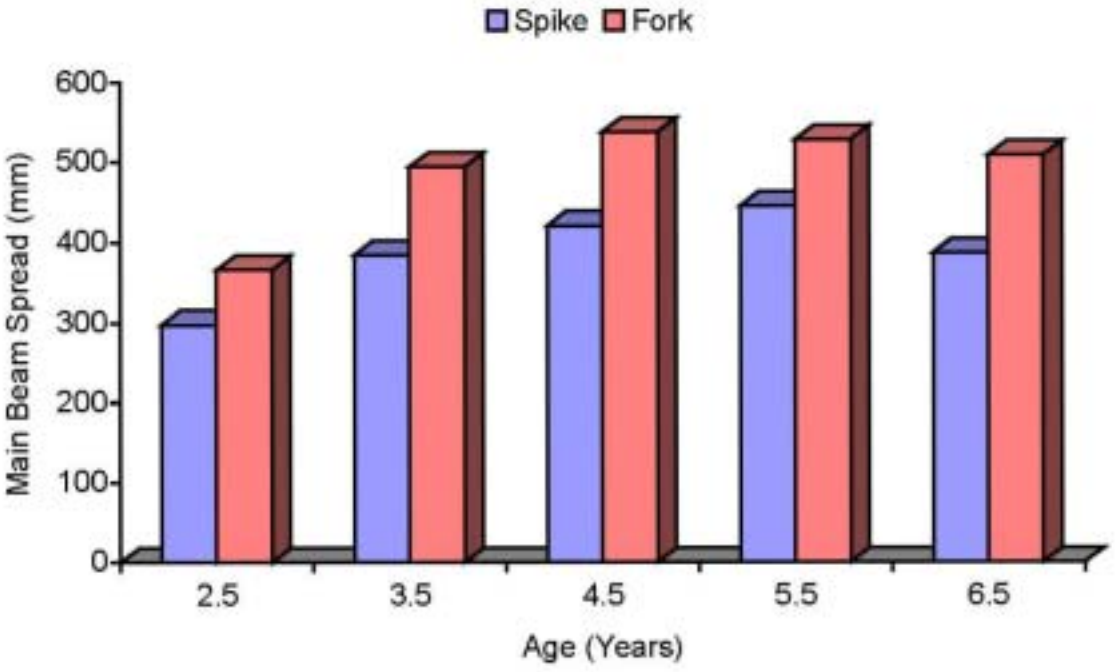

Figure 13. Average main beam spread for white-tailed deer that were classified as spike- or fork-antlered at 1.5 years of age.

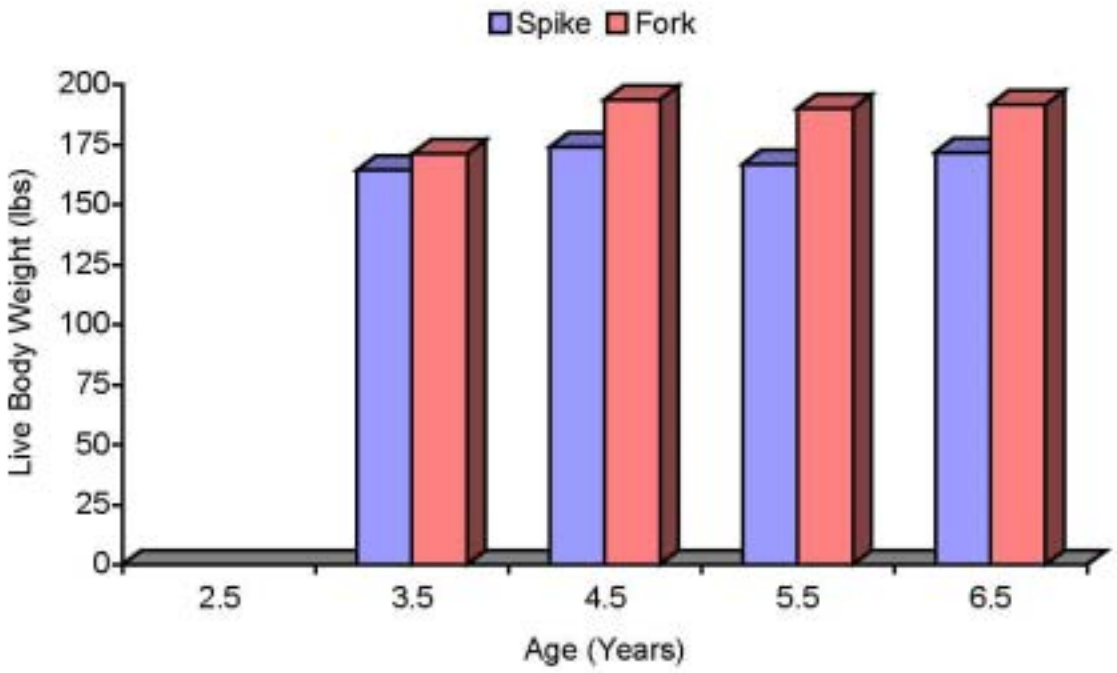

Figure 14. Average live body weight for white-tailed deer that were classified as spike- or fork-antlered at 1.5 years of age.

GENETIC PHASE

Six bucks that were born in 1973 and were spike-antlered as yearlings were bred to groups of doe deer in 2/3-acre deer pen enclosures. The purpose was to produce a genetic line of deer known as the "spike line". Some of the doe fawns born from these matings were maintained in the pens with their sire for a "back-cross" mating for the purpose of concentrating the genes for antler development in the female.

Six to 8 single male breeding pens were used each year. Five to 7 does were placed with each buck. All deer were individually marked, using color coded plastic ear tags (Harmel 1983). All fawns were individually ear-tagged and tattooed at birth, and a card file pedigree record was maintained. A pelleted 16% protein ration similar to the one described by Verme and Ullrey (1972) was provided *ad libitum* (Table 1) to all deer involved in the study.

All male fawns were weaned at 6 to 8 months of age and placed in a 4-acre enclosure. During the last week of October and the first week of November of each year, the male deer were weighed and their antlers removed to 1 to 2 cm above the base. Antler measurements taken at this time included: total number of points (>25 mm in length), maximum inside spread of main beams, basal circumference, main beam lengths, and total antler weight (Table 10). Photographs of each deer were recorded annually.

As the study progressed, some of the original spike line sires died and 2 replacement sires were added to the breeding pens. These replacement sires also had spike antlers as yearlings and were F-1 sons of original sires.

In 1976, a large-bodied, 10-point, 3.5-year-old buck was noted in the pens. This deer had 6 antler points as a yearling and much of his genetic history was known. The decision was made to add this deer to the study as a "fork line" sire and compare his F-1 and back-cross offspring to those sired by the spike brood bucks (spike line).

Table 10. Definitions of symbols used for antler measurements and body weight.

	Symbol[a]	Definition
1	WT	Live body weight (lbs)
2	MB	Length of main beam (mm)
3	AW	Total antler weight (g)
4	BC	Basal circumference of main beam (mm)
5	SI	Maximum inside spread of main beams (mm)
6	TP	Total number of points
7	FORK	Genetic line of deer produced by a sire with 4 antler points at 1.5 years
8	SPIKE	Genetic line of deer produced by a sire with 2 antler points at 1.5 years

[a] Age of buck at time of measurement may be appended to the symbol (WT01 = body weight at 1.5 years of age).

Short History of Sires Used in the Genetic Phase

Sire #73046 – "Leroy"

Leroy was picked up as a fawn near Sisterdale, Texas in Kendall County during the summer of 1973. He was bottle-raised by a private individual, and produced very poor spike antlers as a yearling. Leroy was used as a brood buck from October 21, 1974 to January 30, 1980, and was sent to Texas A & I University for research purposes on February 27, 1980.

Sire #73041

Sire 73041 was picked up as a fawn in Brazos County, Texas and bottle-reared. He produced spike antlers as a yearling, and was used as a brood buck from October 21, 1974 until his death on October 21, 1979. Sire 73041 never produced a set of antlers with more than 4 points. He maintained a distinct red winter fair coat, and passed this characteristic on to many of his offspring.

Sire #73023 – "Rona"

The parents of this sire originated in Walker County, Texas. Rona was born in 1973 and was reared at the Texas A&M University deer pens. He was fed a horse and mule feed diet while growing his first set of antlers. These first antlers were spikes with a small 15mm projection extending from the base of the right antler. Rona was used as a brood buck from October 21, 1974 until his death on October 30, 1978.

Sire # 73009 – " Little Abbey"

The dam of this sire was transferred from the Abilene, Texas zoo to the Kerr Wildlife Management Area on June 5, 1973. Little Abbey was born on June 16, 1973. He was reared by his dam, and fed a horse and mule feed ration (protein content unknown) while growing his first set of antlers. He was used as a brood buck from October 21, 1974 until his death on February 9, 1980.

Sire #73069 – "Little Murph"

The dam of this sire was moved from the Midland, Texas zoo to the Kerr Wildlife Management Area on June 6, 1973. Little Murph (Fig. 15) was born on July 22, 1973, and reared by his dam. Although he was fed a high protein ration (in excess of 16%), he produced a poor set of spike antlers as a yearling. Little Murph was used as a brood buck from October 21, 1974 until his death on October 13, 1978. None of his 4 offspring produced forked antlers as yearlings.

Figure 15. The 2 deer on the right were used as herd sires. The larger deer is "Big Charlie" and the smaller deer on the right is "Little Murph." Big Charlie was used as the "fork line" sire and Little Murph was 1 of the 8 sires used in the "spike line." Both deer are the same age.

Sire #73068

This buck was born in Kerr County, Texas and bottle-reared. He produced spike antlers as a yearling and was used as a brood buck from November 15, 1974 until his death on February 17, 1978.

Sire #75064 – "Murph Jr."

Murph Jr. was born on June 11, 1975 at the Kerr Wildlife Management Area and was the son of Little Murph (73069). He was fed the standard high protein diet and produced spike antlers as a yearling. Murph Jr. produced a set of antlers at 2.5 years which had 4 points and was similar in conformation to his sire. He was used as a brood buck from October 26, 1977 until his death on July 18, 1980.

Sire #77037 – "Scrawny"

Scrawny was born July 14, 1977 and was a back-cross to Sire 73068. As a yearling, Scrawny's antlers were 10mm and 9mm in length and too short to remove without damaging his skull. He was used as a brood buck beginning November 16, 1978.

Sire #73005 – "Big Charlie"

Big Charlie (Fig . 16) was born on June 18, 1973 in the Kerr Wildlife Management Area deer pens, and produced 6 points as a yearling. At 3.5 years, Big Charlie had 10 points and weighed 211 lbs. He was the son of "A&M Charlie" (Fig. 17), a buck which was picked up as a fawn in Milam County, Texas and reared in the Texas A&M University deer pens. A&M Charlie had 8 points at 1.5, 2.5, and 3.5 years of age. When A&M Charlie died at 3.5 years of age, his field dressed weight was 176 lbs. Big Charlie's maternal grandfather, "Salty", (Fig. 18) originated in a captive herd in Maverick County near Eagle Pass, Texas. Salty was a large-bodied deer and grew large sets of antlers while in captivity.

Individual measurements for these 9 sires at 1.5, 2.5, and 3.5 years are shown in Table 11.

Figure 16. "Big Charlie," #73005, was used as the "fork line" sire. At 6.5 years of age he weighed 216 lbs.

Figure 17. "A&M Charlie" (3.5 years of age) was the father of "Big Charlie." He died at 3.5 years of age and his field-dressed weight was 176 lbs.

Figure 18. "Salty" was the maternal grandfather of "Big Charlie." Compare the antler formation between this deer and "Big Charlie" in Fig. 16.

Table 11. Mean body weight and antler measurements for 9 white-tailed deer sires at 1.5, 2.5, and 3.5 years of age.

Sire	Age	WT	MB	AW	IAP	SP	TP
73003	1.5	---	---	---	---	---	0
	2.5	---	467.5	574.50	91.5	47.5	0
	3.5	221	572.0	921.00	108.0	45.5	10
73010	1.5	---	69.5	15.05	48.0	---	2
	2.5	---	112.0	183.00	34.5	20	6
	3.5	267	345.5	220.00	80.0	36.5	7
73025	1.5		105.5	14.50	43.0		2
	2.5	---	325.5	260.50	82.0	32.5	8
	3.5	175	427.5	360.50	89.5	35.0	8
73042	1.5		118.0	30.00	81.5		2
	2.5	---	233.0	121.00	70.0	27.5	4
	3.5	145	252.0	111.00	69.5	32.5	4
73046	1.5		11.0	3.45	23.0		2
	2.5	---	461.0	358.50	86.5	36.8	8
	3.5	---	416.0	260.00	80.0	38.5	8
73068	1.5	---	169.0	15.85	41.0	---	2
	2.5	---	258.5	111.50	63.5	23.0	7
	3.5	255	406.0	240.50	76.0	30.0	9
73069	1.5		43.0	4.25	35.5		2
	2.5	---	241.5	112.50	69.0	25.5	4
	3.5	224	368.5	191.50	72.5	29.7	5
75064	1.5	101	151.0	23.00	43.5	13.3	2
	2.5	134	322.0	128.00	67.5	24.5	4
	3.5	230	386.0	184.50	76.5	13.3	6
77037	1.5	82	91.5		50.0	5.0	2
	2.5	103	74.0	10.75	54.0	---	2
	3.5	91	261.0	99.40	65.5	33.1	4

Total Deer Produced

The 9 sires produced 428 progeny (223 males and 205 females) during the 6 breeding seasons (Table 12). There were 505 sets of antlers available for analysis (Appendix I). These consisted of 150 sets at 1.5, 115 at 2.5, 90 at 3.5, 79 at 4.5, 54 at 5.5, 16 at 6.5, and 1 at 7.5 years of age. Pedigree records were available for 113 of the yearling age class and inbreeding coefficients were calculated. The classification as spike- or fork-antlered at 1.5 years of age for non-inbred and back-cross progeny is shown in Table 13.

There were 64 deer with body weight and antler measurements at 1.5, 2.5, and 3.5 years of age. Only these 64 were used in the analysis because this allowed a more valid comparison between measurements for the 3 age classes.

Table 12. Total progeny (223 males, 205 females) produced by 9 sires during the period 1975–1980

Sire	1975		1976		1977		1978		1979		1980		Total	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
73015	--	--	--	--	11	11	13	15	27	13	26	17	77	56
73019	3	4	5	8	5	5	8	7	9	5	*	*	26	30
73023	1	5	7	6	3	6	10	6	--	--	--	--	21	23
73041	2	4	5	6	6	2	7	7	6	7			26	26
73045	6	1	6	4	32	6	2	2	1	6	--	--	17	13
73068	1	6	5	8	0	4							2	18
73069	4	2	3	1	--	--	--	--	--	--	--	--	7	3
75064	--	--	--	--	--	--	7	11	15	11	8	3	30	25
77063	--	--	--	--	--	--	--	--	6	8	1	3	7	11
Total	17	22	31	33	33	28	42	48	64	51	36	24	223	205

Table 13. Classification of 55 inbred (FX = 0) and 58 non-inbred (FX = 1) progeny from 7 sires as spike- or jerk-antlered at 1.5 years of age

		Classification at age 1.5				
		Spike-antlered		Jerk-antlered		Total progeny
		N	%	N	%	
73019	FX = 1	1	4	22	96	23
	FX = 0	2	20	8	80	10
73023	FX = 1	0	0	2	100	2
	FX = 0	11	69	5	31	13
73023	FX = 1	0	0	2	100	2
	FX = 0		20	4	80	5
73041	FX = 1	2	50	2	50	4
	FX = 0	9	69	4	40	13
73045	FX = 1	2	18	11	85	13
	FX = 0	1	50	1	50	2
73068	FX = 1	1	100	0	0	1
	FX = 0	4	67	2	33	6
73069	FX = 1	4	100	0	0	4
	FX = 0	0	0	0	0	0
77064	FX = 1	6	86	1	14	7
	FX = 0	4	100	0	0	4
77063	FX = 1	1	50	1	50	2
	FX = 0	0	0	0	0	0

Body Weight vs. Total Antler Points

There was a linear relationship between the total number of antler points and body weight within an age class (Table 14). At 1.5 years, the 26 deer which had spike antlers weighed an average of only 97.9 lbs. while deer with 8 or more antler points had an average body weight of over 140.0 lbs. This linear relationship between total antler points and body weight at 1.5, 2.5, and 3.5 years for these 64 deer is shown in Table 29. Table 29 also shows that spike-antlered deer are not only smaller at 1.5 years, but remain small at 2.5 and 3.5 years. The 26 deer that were spike-antlered at 1.5 averaged only 118.08 lbs at 2.5, while the 38 that were fork-antlered at 1.5 had a body weight of 142.97 lbs, a differential of 24.89 lbs. This differential between the buck-cross (TX × 0) and the non-inbred (TX × 0) individuals was 0.87, 6.21, and -0.01 lbs at 1.5, 2.5, and 3.5 years respectively (Table 28).

Table 14. Average live body weight (lbs) versus total antler points for 64 male white-tailed deer at 1.5, 2.5, and 3.5 years of age.

Total	1.5 years		2.5 years		3.5 years	
points	N	Weight	N	Weight	N	Weight
2	5	97.0	4	110.0	3	108.3
3	2	114.0	2	125.0	--	--
4	5	111.8	5	119.0	5	115.8
5	9	120.0	2	137.5	4	133.8
6	6	116.0	6	127.2	4	148.0
7	5	124.8	5	126.2	4	148.0
8	3	140.0	29	140.3	29	140.4
9	1	141.0	4	142.0	9	150.9
10	1	152.0	2	145.5	8	153.3
11					2	158.5
12	--	--	--	--	--	--
13	--	--	1	179.0	1	166.0
Total	64	109.4	64	132.9	64	140.3

Total Antler Points Between Age Classes

The 26 deer that were spike-antlered as yearlings developed antlers that ranged from 2 to 8 points at 2.5 years of age; however, 21 of the 26 had less than 8 antler points. Thirty-one of the 38 that had forked antlers at 1.5 years had 8 or more antler points at 2.5. These data indicate that the probability of a 1.5-year-old spike buck having 8 or more antler points at 2.5 years is 0.19 while the probability of a 1.5 year old fork-antlered deer having 8 or more antler points at 2.5 is 0.82 (Table 15). Only 1 deer had less antler points at 2.5 than at 1.5 and only 4 of the 26 had spike antlers at 2.5. All 4 of these 2.5-year-old spike bucks were spike antlered at 1.5.

Thirty-six of the 38 (94.7%) deer that were fork-antlered at 1.5 had 8 or more antler points at 3.5 (Table 16). However, 17 of the 26 that were spike-antlered at 1.5 had less than 8 points at 3.5. If all spikes had been removed at 1.5, then 94.7% of the remaining deer would have had 8 or more antler points at 3.5. Without removing the spike bucks, only 70.3% of the 3.5 year old deer would have had 8 or more antler points. Again, only 1 deer had less antler points at 3.5 than at 1.5 years and all 3.5 year old spike bucks were spike-antlered at 1.5. These data indicate that the probability

of a fork-antlered yearling having 8 or more antler points at 3.5 years was 0.95 while the probability of a spike-antlered yearling having 8 or more antler points at 3.5 years was only 0.35.

Table 15. Frequency distribution of total antler points for 64 white-tailed deer at 1.5 and 2.5 years of age

Total points at 2.5 years	Total antler points at 1.5 years of age										
	2	3	4	5	6	7	8	9	10	11+	Total deer
12+								1			1
11											0
10				1					1		2
9			1	1	2						4
8	5		3	6	6	0	3				23
7	2		1		2						5
6	1	1	1								3
5	1	1									2
4	8			1							9
3	2										2
2	4										4
Total deer	23	2	6	8	10	0	3	1	1	0	64

Table 16. Frequency distribution of total antler points for 64 white-tailed deer at 1.5 and 3.5 years of age

Total points at 2.5 years	Total antler points at 1.5 years of age										
	2	3	4	5	6	7	8	9	10	11+	Total deer
12+					1						1
11					1			1			2
10				1	5	5	1				12
9	2		1	2	1	2	1				9
8	7	1	4	6	4	1	1		1		25
7	3		1								4
6	3	1									4
5	4										4
4	5										5
3											0
2	2										2
Total deer	26	2	6	9	10	8	3	1	1	0	64

There was also a linear trend between the total antler points at 2.5 and 3.5 years of age (Table 17). There were only 2 animals that had less antler points at 3.5 than at 2.5 years and they were both 10-point deer, which dropped back to 8 points. There were only 4 spike-antlered deer at 2.5 and only 2 spike-antlered deer at 3.5 years. Therefore, if removal of spike bucks is being considered in the management of a deer herd, it is imperative that they be removed at 1.5 years. It will be shown later that although the deer with spike antlers at 1.5 may have more antler points at 2.5 and 3.5, they will be below the average for their age class. All the deer with less than 6 antler points at 3.5 had 4 or less at 2.5 (Table 17), while 14 of the 15 deer that had 4 or less points at 2.5 were spike-antlered at 1.5 (Table 15).

Table 17. Frequency distribution of total antler points for 64 white-tailed deer at 2.5 and 3.5 years of age

Total points at 2.5 years	Total antler points at 1.5 years of age										Total deer
	2	3	4	5	6	7	8	9	10	11+	
12								1			1
11							1			1	2
10							6	2			8
9							8	1			9
8			2	1	1	3	14		3		24
7			1		3						4
6		1		1	2						4
5			4								4
4	2	1	2								5
3											0
2	2										2
Total deer	4	2	9	2	6	3	29	4	2	1	64

Correlation Between Body Weight and Antler Measurements

The simple correlations between measurements at the 3 age classes are given in Tables 18 through 23 for all deer as well as for the spike- and fork-antlered groups. Significant correlations ($P = 0.05$) for $n = 26$, 64, and 38 are 0.38, 0.25, and 0.31, respectively. For $P = 0.01$ the significant values are 0.49, 0.32, and 0.40, respectively. Although the correlations are greater between variables at 1.5 years, there is a strong positive relationship between 1.5- and 3.5-year measurements (Table 20). Within an age class, (Tables 18, 21, and 23) there is very little difference between the correlation coefficients for fork- and spike-antlered deer.

Table 18. Correlation between body weight and antler measurements for 64 (26 spike- and 38 fork-antlered) white-tailed deer at 1.5 years of age

		WT[1]	NP[1]	AW[1]	DP[1]	SB[1]	TB[1]
WT[2]	All	1.00	0.72	0.75	0.75	0.70	0.66
	Spike	1.00	0.54	0.43	0.57	0.57	0.00
	Fork	1.00	0.85	0.68	0.67	0.67	0.57
NP[2]	All	0.72	1.00	0.88	0.85	0.89	0.80
	Spike	0.59	1.00	0.64	0.79	0.90	0.60
	Fork	0.88	1.00	0.84	0.86	0.84	0.75
AW[2]	All	0.75	0.88	1.00	0.85	0.77	0.88
	Spike	0.43	0.64	1.00	0.85	0.81	0.00
	Fork	0.68	0.84	1.00	0.82	0.64	0.83
DP[2]	All	0.75	0.85	0.85	1.00	0.81	0.76
	Spike	0.57	0.79	0.85	1.00	0.74	0.00
	Fork	0.67	0.86	0.82	1.00	0.46	0.57
SB[2]	All	0.70	0.89	0.77	0.8	1.00	0.68
	Spike	0.57	0.90	0.81	0.74	1.00	0.00
	Fork	0.67	0.84	0.64	0.46	1.00	0.43
TB[2]	All	0.66	0.80	0.88	0.76	0.68	1.00
	Spike	0.00	0.00	0.0	0.00	0.00	1.00
	Fork	0.52	0.75	0.83	0.57	0.43	1.00

Table 19. Correlation between body weight and antler measurements for 64 (26 spike- and 38 fork-antlered) white-tailed deer at 1.5 and 2.5 years of age.

		WT (kg)	ME (cm)	AA (cm²)	IB (cm)	SD (cm)	TP (cm)
WT (kg)	All	0.85	0.71	0.67	0.65	0.66	0.64
	Spike	0.75	0.60	0.35	0.39	0.53	0.01
	Fork	0.81	0.15	0.50	0.61	0.41	0.36
ME (cm)	All	0.71	0.81	0.89	0.84	0.71	0.86
	Spike	0.46	0.54	0.33	0.25	0.48	0.01
	Fork	0.68	0.76	0.87	0.81	0.88	0.48
AA (cm²)	All	0.78	0.86	0.88	0.77	0.78	0.80
	Spike	0.53	0.74	0.63	0.54	0.64	0.01
	Fork	0.69	0.81	0.78	0.65	0.84	0.64
IB (cm)	All	0.78	0.81	0.88	0.78	0.74	0.87
	Spike	0.57	0.72	0.65	0.48	0.74	0.01
	Fork	0.67	0.64	0.68	0.77	0.46	0.48
SD (cm)	All	0.61	0.66	0.67	0.68	0.72	0.67
	Spike	0.56	0.49	0.36	0.45	0.63	0.01
	Fork	0.81	0.81	0.80	0.84	0.66	0.24
TP (cm)	All	0.52	0.74	0.61	0.64	0.56	0.69
	Spike	0.29	0.52	0.32	0.38	0.45	0.01
	Fork	0.27	0.52	0.39	0.22	0.31	0.52

Table 20. Correlation between body weight and antler measurements for 64 (26 spike- and 38 fork-antlered) white-tailed deer at 3.5 and 4.5 years of age.

		WT (kg)	ME (cm)	AA (cm²)	IB (cm)	SD (cm)	TP (cm)
WT (kg)	All	0.78	0.60	0.56	0.65	0.63	0.52
	Spike	0.66	0.61	0.41	0.43	0.56	0.01
	Fork	0.69	0.22	0.41	0.47	0.43	0.17
ME (cm)	All	0.62	0.79	0.61	0.58	0.65	0.62
	Spike	0.50	0.48	0.28	0.31	0.44	0.01
	Fork	0.47	0.64	0.54	0.36	0.56	0.55
AA (cm²)	All	0.71	0.81	0.83	0.77	0.70	0.77
	Spike	0.42	0.69	0.58	0.57	0.61	0.01
	Fork	0.61	0.71	0.75	0.66	0.59	0.66
IB (cm)	All	0.69	0.72	0.71	0.74	0.70	0.59
	Spike	0.51	0.66	0.60	0.46	0.68	0.01
	Fork	0.62	0.54	0.68	0.82	0.45	0.53
SD (cm)	All	0.44	0.51	0.49	0.51	0.60	0.48
	Spike	0.28	0.38	0.38	0.28	0.41	0.01
	Fork	0.33	0.54	0.45	0.47	0.63	0.44
TP (cm)	All	0.51	0.68	0.58	0.66	0.66	0.63
	Spike	0.37	0.50	0.43	0.44	0.41	0.01
	Fork	0.20	0.30	0.33	0.26	0.36	0.42

Table 21. Correlation between body weight and antler measurements for 64 (26 spike- and 38 fork-antlered) white-tailed deer at 2.5 years of age

		WT×2	MB×2	AW×2	IP×2	SP×2	TP×2
WT×2	All	1.00	0.71	0.76	0.75	0.64	0.57
	Spike	1.00	0.55	0.58	0.60	0.59	0.36
	Fork	1.00	0.57	0.61	0.67	0.47	0.28
MB×2	All	0.71	1.00	0.87	0.81	0.79	0.74
	Spike	0.55	1.00	0.88	0.69	0.64	0.67
	Fork	0.57	1.00	0.82	0.72	0.75	0.48
AW×2	All	0.76	0.87	1.00	0.88	0.69	0.77
	Spike	0.58	0.88	1.00	0.83	0.60	0.74
	Fork	0.61	0.82	1.00	0.84	0.68	0.62
IP×2	All	0.75	0.81	0.88	1.00	0.72	0.67
	Spike	0.60	0.69	0.83	1.00	0.71	0.51
	Fork	0.67	0.72	0.84	1.00	0.74	0.47
SP×2	All	0.64	0.79	0.69	0.72	1.00	0.56
	Spike	0.59	0.64	0.60	0.71	1.00	0.36
	Fork	0.47	0.75	0.68	0.74	1.00	0.62
TP×2	All	0.57	0.74	0.77	0.67	0.56	1.00
	Spike	0.36	0.67	0.74	0.51	0.36	1.00
	Fork	0.28	0.48	0.64	0.41	0.34	1.00

Table 22. Correlation between body weight and antler measurements for 64 (26 spike- and 38 fork-antlered) white-tailed deer at 2.5 and 3.5 years of age

		WT×2	MB×2	AW×2	IP×2	SP×2	TP×2
WT×3	All	0.87	0.66	0.67	0.77	0.63	0.52
	Spike	0.82	0.72	0.73	0.66	0.72	0.50
	Fork	0.87	0.56	0.48	0.84	0.41	0.48
MB×3	All	0.86	0.88	0.86	0.71	0.72	0.72
	Spike	0.84	0.89	0.83	0.66	0.65	0.66
	Fork	0.81	0.71	0.65	0.88	0.80	0.68
AW×3	All	0.80	0.84	0.91	0.83	0.69	0.78
	Spike	0.87	0.82	0.93	0.78	0.68	0.76
	Fork	0.93	0.65	0.83	0.74	0.54	0.64
IP×3	All	0.69	0.70	0.77	0.91	0.66	0.62
	Spike	0.61	0.63	0.77	0.81	0.71	0.44
	Fork	0.62	0.54	0.71	0.84	0.43	0.42
SP×3	All	0.42	0.54	0.56	0.56	0.79	0.48
	Spike	0.19	0.34	0.37	0.50	0.74	0.28
	Fork	0.31	0.54	0.53	0.40	0.73	0.58
TP×3	All	0.53	0.71	0.69	0.64	0.54	0.84
	Spike	0.48	0.68	0.71	0.47	0.48	0.87
	Fork	0.16	0.54	0.43	0.36	0.56	0.47

Table 23. Correlation between body weight and antler measurements for 64 (26 spike- and 38 fork-antlered) white-tailed deer at 3.5 years of age.

		WT03	ME03	AA03	PO03	SP03	TP03
WT03	All	1.00	0.51	0.66	0.64	0.45	0.52
	Spike	1.00	0.69	0.72	0.68	0.46	0.58
	Fork	1.00	0.12	0.41	0.52	0.21	0.43
ME03	All	0.51	1.00	0.85	0.80	0.69	0.73
	Spike	0.69	1.00	0.85	0.83	0.49	0.24
	Fork	0.12	1.00	0.82	0.56	0.65	0.69
AA03	All	0.66	0.85	1.00	0.82	0.64	0.75
	Spike	0.74	0.85	1.00	0.81	0.52	0.80
	Fork	0.41	0.82	1.00	0.78	0.63	0.29
PO03	All	0.64	0.80	0.82	1.00	0.63	0.59
	Spike	0.68	0.83	0.81	1.00	0.58	0.48
	Fork	0.52	0.56	0.78	1.00	0.60	0.44
SP03	All	0.45	0.69	0.64	0.63	1.00	0.50
	Spike	0.46	0.49	0.52	0.58	1.00	0.55
	Fork	0.21	0.65	0.63	0.60	1.00	0.38
TP03	All	0.52	0.73	0.75	0.59	0.50	1.00
	Spike	0.58	0.24	0.80	0.48	0.55	1.00
	Fork	0.43	0.69	0.29	0.44	0.38	1.00

Progeny Averages for the Nine Sires
(Tables 24 - 26)

Data for the 64 progeny are compared at 1.5, 2.5, and 3.5 years. None of the sires represented in the spike line produced averages which were comparable to the 15 progeny produced by the sire of the fork line (730035).

Table 24. Mean body weight and antler measurements for 1.5 year old progeny from 9 white-tailed deer sires.

Sire	N	WT01	AB01	AA01	PO01	SP01	TP01
730035	15	128.67	297.73	138.09	70.70	255.47	6.60
730069	11	108.00	167.17	33.91	54.55	187.22	2.67
730025	4	111.25	288.88	70.63	69.38	196.25	4.25
730427	12	109.25	207.75	88.40	61.67	21.08	4.00
730466	5	111.60	258.00	94.57	62.20	235.00	5.40
730668	4	86.50	153.00	42.93	49.88	151.25	3.75
730669	1	106.00	165.00	23.00	43.50	133.00	2.00
750624	12	96.50	129.67	30.52	44.92	130.33	2.75
770457	2	80.50	141.50	35.93	56.00	138.50	3.50
---	64	109.42	202.09	70.44	58.78	197.52	4.25

Table 25. Mean body weight and antler measurements for 2 ½-year-old progeny from 9 white-tailed deer sires

Sire	N	WT02	ME02	AA02	BC02	SD02	TP02
73015	15	153.00	432.97	329.85	88.83	374.87	8.47
73019	9	126.00	367.89	180.28	77.56	301.56	5.22
73025	4	154.25	375.00	198.26	79.00	297.25	7.50
73047	12	132.17	361.46	189.54	75.46	295.08	5.92
73046	5	158.60	374.50	261.00	81.00	315.20	8.20
73068	4	109.50	252.88	151.98	64.13	264.00	6.75
73069	1	154.00	320.00	128.00	67.50	255.00	4.00
73062	12	120.75	321.04	138.63	68.67	278.25	5.83
77037	2	138.50	333.75	214.00	74.00	283.00	7.50
	61	132.86	342.11	222.97	77.48	312.02	6.75

Table 26. Mean body weight and antler measurements for 3 ½-year-old progeny from 9 white-tailed deer sires

Sire	N	WT03	ME03	AA03	BC03	SD03	TP03
73015	15	166.27	483.53	312.64	97.47	408.20	9.33
73019	9	142.11	464.28	263.22	91.22	376.89	7.00
73025	4	157.50	408.63	257.50	94.00	338.75	8.50
73047	12	148.08	364.46	209.13	87.88	329.33	6.42
73046	5	147.40	428.60	283.48	89.00	341.40	9.20
73068	4	118.25	364.00	236.48	75.88	319.25	7.25
73069	1	150.00	380.00	184.50	76.50	133.00	5.00
73062	12	129.25	406.92	261.15	82.58	338.92	6.83
77037	2	160.00	430.00	329.25	85.25	370.00	8.00
	61	146.36	426.08	345.71	89.69	356.73	7.69

Progeny Averages for Spike and Fork Line

The averages for the spike line were consistently lower than for the fork line (Table 27). The differences were approximately 20 lbs for body weight and 2 antler points. However, the most pronounced difference is in antler weight.

Table 27. Comparison of Body weight and antler measurements between the "fork line" and "spike line" at 1 ½, 2 ½, and 3 ½ years of age

	N	WT01	ME01	AA01	BC01	SD01	TP01
FORK	15	138.67	307.13	134.08	80.47	299.47	6.60
SPIKE	49	103.53	271.71	57.08	55.13	180.18	3.55
	N	WT02	ME02	AA02	BC02	SD02	TP02
FORK	15	153.00	432.97	329.85	88.83	374.87	8.47
SPIKE	49	126.69	353.69	171.95	74.00	292.98	6.22
	N	WT03	ME03	AA03	BC03	SD03	TP03
FORK	15	166.27	483.53	312.64	97.47	408.20	9.33
SPIKE	49	140.18	395.43	204.61	86.53	338.37	7.18

Back-Cross vs. Non-Inbred (Spike Line)

Since only one of the fork line deer was a back-cross, only data for the spike line are compared (Table 28). Of the 49 in the spike line, 4 could not be used due to incomplete information concerning the dam. Data for the 45 remaining are compared in Table 28. These data show very little difference between the F-1 and back-cross progeny. This is not surprising since all progeny were used without selection and there was no progeny testing used to select the dams. If both the dam and sire were heterozygous for a trait, then a back-cross without selection would not concentrate a specific genetic combination.

Table 28. Comparison of body weight and antler measurements between non-inbred (2N ++) and back-cross or inbred (2N --) progeny at 1.5, 2.5, and 3.5 years of age.

	N	WT+0	M+0	AW+0	B+0	SP0	TP0
2N ++	13	102.00	198.77	58.50	84.40	185.15	8.85
2N --	32	105.13	201.71	57.66	85.08	178.97	8.32
	N	WT+2	M+2	AW+2	B+2	SP+2	TP02
2N ++	13	130.46	247.23	193.92	94.23	290.00	7.08
2N --	32	124.25	236.86	165.31	93.94	291.00	5.69
	N	WT+3	M+3	AW+3	B+3	SP03	TP03
2N ++	13	140.15	265.38	314.15	94.42	327.92	8.85
2N --	32	140.16	329.50	280.47	87.06	340.81	6.66

Comparison of 64 Deer

Data from 64 white-tailed deer were classified according to number of antler points at 1.5 years and then compared at 1.5, 2.5, and 3.5 years.

These data indicate that average body weight (Table 29), average main beam length (Table 30), average antler weight (Table 31), average basal circumference (Table 32), and average main beam spread (Table 33) are all related to the total antler points at 1.5 years and that this relationship is maintained through 3.5 years. Basal circumference at 2.5 and 3.5 years seems to be least affected by total antler points at 1.5 years.

Table 29. Average live body weight for 64 white-tailed deer at 1.5, 2.5, and 3.5 years of age.

N	Antler points (1.5 years)	Average body weight (lbs)		
		1.5 years	2.5 years	3.5 years
26	2	97.88	158.08	178.04
2	3	114.20	129.00	150.00
6	4	117.50	156.83	193.67
9	5	109.00	136.00	152.22
10	6	110.50	138.70	152.40
6	7	124.83	140.33	152.50
4	8	140.00	169.33	221.33
1	9	141.00	179.00	289.00
1	10	152.00	172.00	198.00
64	--	109.42	143.80	166.00

Table 30. Average main beam length for 64 white-tailed deer at 1.5, 2.5, and 3.5 years of age.

N	Antler points (1.5 years)	Average main beam length (mm)		
		1.5 years	2.5 years	3.5 years
26	2	121.04	282.04	369.52
7	3	161.50	345.00	380.25
6	4	229.17	370.33	416.50
9	5	220.00	343.56	414.22
10	6	252.70	385.30	457.50
6	7	310.75	429.50	489.33
3	8	321.17	328.33	491.50
1	9	336.00	417.50	506.50
1	10	331.50	445.00	452.00
64	--	201.09	342.42	426.08

Table 31. Average antler weight for 64 white-tailed deer at 1.5, 2.5, and 3.5 years of age.

N	Antler points (1.5 years)	Average antler weight (g)		
		1.5 years	2.5 years	3.5 years
26	2	28.56	123.28	230.73
7	3	47.20	168.80	210.13
6	4	65.56	251.78	327.51
9	5	86.02	243.67	393.64
10	6	103.56	269.46	419.57
6	7	150.18	434.50	487.83
3	8	201.67	362.22	580.88
1	9	138.25	630.85	865.70
1	10	209.05	454.55	558.65
64	--	76.44	222.07	345.71

Table 32. Average basal circumference for 64 white-tailed deer at 1.5, 2.5, and 3.5 years of age.

N	Antler points (1.5 years)	Average basal circumference (mm)		
		1.5 years	2.5 years	3.5 years
26	2	47.40	68.98	82.44
7	3	58.78	72.78	80.75
6	4	62.08	82.06	90.50
9	5	59.00	79.17	91.33
10	6	64.05	82.65	91.95
6	7	71.83	88.00	95.50
3	8	74.17	91.67	105.33
1	9	72.50	105.50	110.00
1	10	79.00	88.50	90.50
64	--	58.78	77.48	89.02

Table 33. Average main beam spread for 74 white-tailed deer at 1.5, 2.5, and 3.5 years of age

N	Antler points (2.5 years)	Average main beam spread (cm)		
		1.5 years	2.5 years	3.5 years
26	2	141.77	278.20	320.12
2	3	196.00	290.50	298.50
6	4	220.17	355.17	356.67
9	5	215.33	311.89	373.00
10	6	239.10	325.20	368.60
7	7	257.67	360.17	425.33
3	8	275.00	336.33	362.33
1	9	270.00	339.00	430.00
1	10	290.00	408.00	485.00
66	--	197.86	312.02	354.73

Comparison of 26 Spike-Antlered Deer

Data from 26 male white-tailed deer which were spike-antlered at 1.5 years (Tables 34-39) were classified according to total antler points at 2.5 years and compared at 1.5, 2.5, and 3.5 years. These data indicate that although 35% produced 8 or more points at 3.5 years, they were not of the same quality as those which were fork-antlered at 1.5 years (Tables 40-44). Eleven, or 42%, produced 5 or less antler points at 3.5 years.

Table 34. Distribution of antler points at 2.5 and 3.5 years of age for 26 deer that were spike-antlered at 1.5 years

N	Total antler points		
	1.5 years	2.5 years	3.5 years
4	2	2	2,2,2,4
2	2	3	4,6
5	2	4	4,4,5,5,5
1	2	5	6
4	2	6	5,7,7,8
2	2	7	8,8
8	2	8	8,8,8,9,9

Table 35. Average live body weight at 1.5, 2.5, and 3.5 years of age for 26 deer that were spike-antlered at 1.5 years

N	Antler points (2.5 years)	Average body weight (lbs)		
		1.5 years	2.5 years	3.5 years
4	2	85.75	109.00	105.00
2	3	100.00	123.00	130.50
8	4	97.00	113.88	137.13
1	5	120.00	142.00	161.00
4	6	103.50	113.75	146.00
2	7	97.50	116.50	142.50
5	8	99.20	126.50	148.20
26		97.88	118.08	131.04

Table 36. Average main beam length at 1.5, 2.5, and 3.5 years of age for 26 deer that were spike-antlered at 1.5 years.

N	Antler points (1.5 years)	Average main beam length (mm)		
		1.5 years	2.5 years	3.5 years
4	2	88.75	160.88	248.75
2	3	48.00	266.25	325.75
8	4	176.25	298.50	377.38
1	5	232.50	368.50	406.00
4	6	188.13	281.88	384.63
2	7	107.25	292.25	401.75
5	8	161.20	349.80	434.20
26	--	121.02	282.02	368.52

Table 37. Average total antler weight at 1.5, 2.5, and 3.5 years of age for 26 deer that were spike-antlered at 1.5 years.

N	Antler points (1.5 years)	Average antler weight (g)		
		1.5 years	2.5 years	3.5 years
4	2	9.63	35.80	100.25
2	3	5.50	61.25	85.88
8	4	31.45	121.02	214.72
1	5	61.85	191.50	317.15
4	6	41.63	134.75	262.13
2	7	23.40	148.38	268.96
5	8	33.00	176.80	321.06
26	--	28.56	123.28	230.73

Table 38. Average basal circumference at 1.5, 2.5, and 3.5 years of age for 26 deer that were spike-antlered at 1.5 years.

N	Antler points (1.5 years)	Average basal circumference (mm)		
		1.5 years	2.5 years	3.5 years
4	2	38.38	56.75	69.50
2	3	41.25	63.50	80.25
8	4	47.19	69.13	81.00
1	5	53.50	86.50	105.00
4	6	54.00	73.38	90.63
2	7	52.50	67.75	81.00
5	8	48.60	73.40	89.80
26	--	47.40	68.98	82.44

Table 39. Average main beam spread at 1.5, 2.5, and 3.5 years of age for 26 deer that were spike-antlered at 1.5 years

N	Antler points (2.5 years	Average main beam spread (mm)		
		1.5 years	2.5 years	3.5 years
4	2	78.75	203.67	286.25
2	3	111.50	281.50	340.50
8	4	136.25	273.25	311.75
1	5	231.00	392.00	385.00
4	6	175.50	275.50	340.00
2	7	118.50	268.50	339.00
5	8	172.80	286.80	347.20
26	--	141.77	275.50	326.12

Comparison of 38 Fork-Antlered Deer

Data from 38 male white-tailed deer that were fork-antlered at 1.5 years (Tables 40-44) were classified according to total antler points at 2.5 years and compared at 1.5, 2.5, and 3.5 years. Table 16 indicates that 36, or 95% of these deer produced 8 or more points at 3.5 years and none produced less than 6 antler points. When Tables 35-39 are compared with Tables 40-44, the deer that were fork-antlered at 1.5 years averaged 25.7 lbs greater body weight at 3.5 years, 78.41 mm longer main beam length, 193.66 g heavier total antler weight, 11.2 mm greater basal circumference, and 48.2 mm wider main beam spread.

Table 40. Average live body weight at 1.5, 2.5, and 3.5 years of age for 38 deer that were fork antlered at 1.5 years

N	Antler points (2.5 years	Average body weight (lbs)		
		1.5 years	2.5 years	3.5 years
1	4	101.00	128.00	139.00
1	5	109.00	133.00	143.00
2	6	120.00	154.00	179.50
3	7	101.00	129.33	146.33
24	8	118.71	143.25	157.96
4	9	115.75	142.00	147.00
2	10	120.50	145.50	161.00
1	13	141.00	179.00	189.00
38	--	117.52	142.97	156.74

Table 41. Average main beam length at 1.5, 2.5, and 3.5 years of age for 38 deer that were fork-antlered at 1.5 years.

N	Antler points (1.5 years)	Average main beam length (mm)		
		1.5 years	2.5 years	3.5 years
1	4	164.00	356.00	373.50
1	5	129.50	338.00	387.50
2	6	238.00	420.50	444.25
3	7	197.67	330.50	420.83
26	8	270.08	387.19	456.13
4	9	230.38	404.25	468.13
2	10	278.25	388.00	440.25
1	13	339.00	517.50	566.50
38	--	255.86	383.72	447.03

Table 42. Average total antler weight at 1.5, 2.5, and 3.5 years of age for 38 deer that were fork-antlered at 1.5 years.

N	Antler points (1.5 years)	Average antler weight (g)		
		1.5 years	2.5 years	3.5 years
1	4	53.50	70.20	168.00
1	5	28.00	171.25	211.50
2	6	79.25	292.50	236.43
3	7	66.30	163.73	367.58
26	8	121.50	299.05	449.08
4	9	84.63	290.38	456.13
2	10	132.47	388.08	481.25
1	13	138.25	630.85	665.70
38	--	107.92	297.18	474.09

Table 43. Average basal circumference at 1.5, 2.5, and 3.5 years of age for 38 deer that were fork-antlered at 1.5 years.

N	Antler points (1.5 years)	Average basal circumference (mm)		
		1.5 years	2.5 years	3.5 years
1	4	51.50	67.50	84.50
1	5	60.00	82.00	82.00
2	6	63.50	87.50	87.25
3	7	57.67	73.17	86.17
26	8	68.62	82.69	89.44
4	9	62.38	85.00	92.25
2	10	66.00	89.25	94.25
1	13	72.50	105.50	110.00
38	--	66.37	83.29	92.64

Table 44. Average main beam spread at 1.5, 2.5, and 3.5 years of age for 38 deer that were fork-antlered at 1.5 years.

N	Antler points (1.5 years)	Average main beam spread (mm)		
		1.5 years	2.5 years	3.5 years
1	4	228.00	227.00	355.00
1	5	142.00	290.00	302.00
2	6	241.50	350.50	326.00
3	7	183.67	281.00	334.00
24	8	242.79	341.38	380.50
4	9	253.50	376.25	397.25
2	10	230.00	339.50	381.00
1	13	270.00	339.00	430.00
38	--	236.18	336.24	374.32

HERITABILITY ESTIMATES

This study was not designed to estimate the heritability of body weight and antler measurements. The high correlations between first- and third-year measurements indicate that these traits are highly heritable. The phenotypic resemblance between father and son, evident in the photographs (Figs 19-20), also indicate that these traits are highly heritable. According to Falconer (1960):

In experimental and domesticated populations, the parents are often a selected group and consequently the phenotypic variance among the parents is less than that of the population as a whole and less than that of the offspring. The regression of offspring on parents, however, is not affected by the selection of parents because the covariance is reduced to the same extent as the variance of the parents, so that the slope of the regression line is unaltered. Thus the regression of offspring on one parent is a valid measure of ½ h(2), and that of offspring on mid-parent is a valid measure of h(2).

Figure 19. Sire #73041 at 5.5 years produced 4 non-inbred and 15 inbred offspring, one of which is pictured in Fig. 20, also at 5.5 years of age.

Heritability estimates were calculated using regression of offspring on sire and are shown in Table 45. These estimates have very large standard errors due to small numbers of individuals per sire and because there was no phenotypic selection for the male. This lack of selection in the female segment of the breeding population would not reduce the phenotypic variance among progeny as suggested by Falconer when both parents were selected.

According to Lush (1945):

In the strictest sense of the word, the question of whether a characteristic is hereditary or environmental has no meaning. Every characteristic is both hereditary and environmental, since it is the end result of a long chain of interactions of the genes with each other, with the environment and with the intermediate products at each stage of development [(Fig. 21)]. The genes cannot develop the characteristic unless they have the proper environment, and no amount of attention to the environment will cause the characteristic to develop unless the necessary genes are present. If either the genes or the environment are changed, the characteristic that results from their interactions may be changed.

The whole matter of whether a characteristic is hereditary or environmental, if we find it convenient to state it in that way, is a question of how much of the variation in that characteristic in that population is caused by differences in heredity and how much is caused by differences in environment.

Figure 20. A 5.5-year-old inbred offspring sired by #73041. Note the similarities in points and antler confirmations. Both sire and offspring were spike-antlered as yearlings.

Table 45. Heritability estimates, using regression of offspring on sire, for body weight and antler measurements for 1.5-, 2.5-, and 3.5-year-old white-tailed deer.

	Heritability (standard error)		
Trait	1.5 year	2.5 year	3.5 year
WT	--	0.38 (0.08)	0.48 (0.28)
MB	0.80 (0.52)	0.52 (0.26)	0.57 (0.24)
AW	1.41 (0.50)	0.41 (0.12)	0.28 (0.10)
BC	0.63 (0.52)	1.08 (0.34)	0.80 (0.29)
SP	--	0.93 (0.30)	0.55 (0.58)
TP	--	0.66 (0.38)	0.75 (0.36)

CONCLUSIONS

1. Body weight and antler characteristics (main beam spread and lengths, basal circumference, total antler points, and weight) in white-tailed deer respond in direct proportions to the quality of their diet.
2. Antler characteristics and body weight of white-tailed deer are heritable characters and influenced by both genetics and nutrition.
3. Yearling white-tailed deer with spike antlers are inferior to fork-antlered yearlings with regard to body weight and antler characteristics and will remain so in succeeding years.
4. There is a positive correlation between body weight and total antler points in yearling deer.
5. Spike-antlered deer should not receive differential protection.
6. Most deer which are spike-antlered as yearlings will not be spike-antlered in later years, but will continue to be inferior to their fork-antlered cohorts.

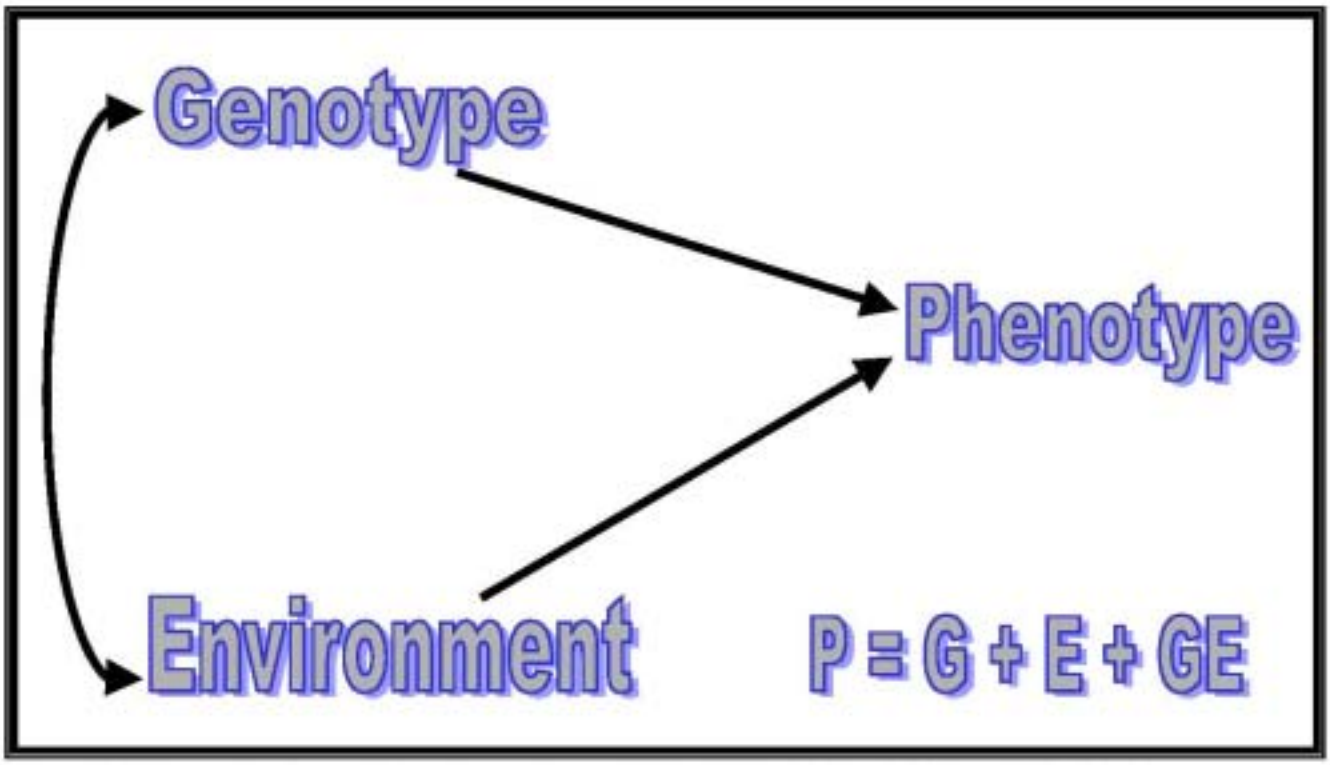

Figure 21. Phenotypic characteristics such as antlers and body weight of white-tailed deer are heritable characters, which are influenced by both genetics and nutrition and the interaction of the 2 factors.

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Appendix I
Data Used in This Study

Definition of Variables

Variable	Description
OBS	Sequence number
BDATE	Birth date
BWT	Birth Weight
BYR	Birth year
PROGID	Progeny identification number
SIRID	Sire identification number
DAMNID	Dam identification number
YEAR	Year of measurement
WT	Body weight (lbs)
SPREAD	Maximum inside main beam spread (mm)
MBLEFT	Length of left antler main beam (mm)
MBRITE	Length of right antler main beam (mm)
BCLEFT	Basal circumference of left antler (mm)
BCRITE	Basal circumference of right antler (mm)
PTSL	Total points of left antler
PTSR	Total points of right antler
AWTL	Total weight of left antler (g)
AWTR	Total weight of right antler (g)
TPTS	Total antler points
SET	Year of age of deer for antler development (1 = 1.5 years, etc.)

Appendix II
Publications Resulting From This Study

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