2010

White-Tailed Deer Antler Research: A Response to Demarais and Strickland

Ben Koerth

James Kroll
Arthur Temple College of Forestry and Agriculture, Stephen F. Austin State University, jkroll@sfasu.edu

Journal of Wildlife Management 74(2):198–202; 2010; DOI: 10.2193/2009-192

Commentary

White-Tailed Deer Antler Research: A Response to Demarais and Strickland

BEN H. KOERTH,[1] *Arthur Temple College of Forestry and Agriculture, Stephen F. Austin State University, Nacogdoches, TX 75962, USA*
JAMES C. KROLL, *Arthur Temple College of Forestry and Agriculture, Stephen F. Austin State University, Nacogdoches, TX 75962, USA*

ABSTRACT Demarais and Strickland presented several questions about the scope and validity of conclusions regarding predictability of mature antler size based on yearling antler size and produced a simulation model reported to demonstrate measurement bias in our 2008 study. We believe our conclusions were appropriate with our research hypothesis and demonstrated the assumed differential selection bias by hunters used in Demarais and Strickland was unwarranted. Demarais and Strickland provided no metadata to document the provenance of data used in their model and did not account for location, year, cohort, nutrition of research animals, or loss of individuals from their sample population by accidents or death: the same questions raised in their critique. Additionally, selection and experimental design problems in a portion of their sample population indicate their model results are questionable. Our responses to Demarais and Strickland will aid wildlife managers in making future culling decisions in white-tailed deer management.

KEY WORDS antler development, *Odocoileus virginianus*, Texas, white-tailed deer.

In recent years placing antler restrictions on white-tailed deer (*Odocoileus virginianus*) males has generated scientific and political controversy. Primarily through grassroots efforts, landowners and sportsmen in several states have influenced regulations on legal males for harvest. The stated purpose of these restrictions was to increase the number of older males in the population, thereby increasing antler quality of males in the harvest (Bullock et al. 1995, Demarais 1998). One of the earliest antler restriction studies was the Dooly County project in Georgia, USA, where antler restrictions were based on outside antler spread (Hamilton et al. 1995). After observing the antler restriction success in Dooly County, other states implemented antler restrictions with varied restriction criteria. However, number of antler points seems to be a common criterion for establishing harvest restrictions (e.g., Texas Parks and Wildlife Department 2006, Arkansas Game and Fish Commission 2009, Michigan Department of Natural Resources 2009, Mississippi Department of Wildlife, Fisheries and Parks 2009, Pennsylvania Game Commission 2009) designed to protect younger age classes of males. Although receiving high public acceptance, antler restrictions have met with resistance from some sportsmen's groups and professional biologists (Duda et al. 1998). Strickland et al. (2001) and Demarais et al. (2005) asserted antler point restrictions in Mississippi would result in long-term problems because of potential negative biological effects. Both studies were based on models similar to the one used in Demarais and Strickland (2010).

In our antler growth study (Koerth and Kroll 2008), we were motivated by the controversy stemming from 2 studies conducted in Texas, USA, and Mississippi, USA, that resulted in conflicting results (Williams et al. 1994, Lukefahr and Jacobson 1998, Ott et al. 1998). The Texas Parks and Wildlife Department study at Kerr Wildlife Management Area (KWMA) concluded the number of antler points of yearling males was a good predictor of mature antler size (Ott et al. 1998). The Mississippi State University study showed the number of antler points on yearling males could not be used reliably to predict antler growth potential (Lukefahr and Jacobson 1998). The contradictory nature of the above studies caused misunderstanding and misconceptions on the part of landowners, hunters, and managers. Both of the above studies were conducted in research pens where many of the animals had a known history, were held at unnaturally high densities, and fed a high-quality diet ad libitum. It was unknown if either result would apply on a large scale to wild populations that experience varying range and management conditions. In this context we designed and conducted our study on free-living populations.

Demarais and Strickland (2010) critiqued the following issues in our study (Koerth and Kroll 2008):

1. We did not state a statistical hypothesis, and the one we tested did not coincide with our specific conclusions. Thus, our statistical analysis provided an evaluation of a unique harvest-based culling system instead of predictability of antler size at maturity based number of points on the first set of antlers.
2. We introduced a measurement bias and a level of incomplete repeated measures by the removal of deer by legal harvest during our study.
3. The conditions of our study did not allow extrapolation to other white-tailed deer populations.
4. Our study areas represented a special case, especially if the asserted culling bias was considered.

Based on these perceived biases, Demarais and Strickland (2010) used an undisclosed mathematical model based on their interpretation of our experimental design, our results, and unpublished data from 3 geographically and temporally disparate data sets from Georgia, Mississippi, and Texas. Our objective for this manuscript was to reevaluate our data to assess the merits of the criticisms by Demarais and Strickland (2010).

[1] *E-mail: bkoerth@sfasu.edu*

RESPONSE TO CRITICISMS

Criticism 1

Hypothetico-deductive research employs the following steps: theory, research hypothesis, statistical hypothesis, testing (design and data collection), and testing of results (Romesburg 1981). Also, a priori research is less likely to generate bias than a posteriori models. In Koerth and Kroll (2008:1109), we stated the following: "Our objective was to determine if a whitetail male's first set of antlers was a good indicator of antler growth at maturity ($\geq$4.5 yr old) in wild populations." An objection by Demarais and Strickland (2010:193) was whether the statistical hypothesis tested actually was "…based on an evaluation of the effectiveness of harvest-based culling criteria," rather than on our stated research hypothesis. Although we can concede a statistical hypothesis should have been stated differently, we feel our conclusions remain valid. Our 2 subpopulations of yearling males were based on antler configuration. One group started low on the scale based on number of antler points, the other started higher. At the age of $\geq$4.5 years we found no difference in any antler metric or gross Boone and Crockett (B&C) score between the 2 groups (Koerth and Kroll 2008). Thus, we concluded neither antler grouping of yearling males was a good predictor of mature antler size. Because of that conclusion, we believe the purposeful removal of yearling males based on the number of points on their first set of antlers would not have a significant effect on overall antler size at maturity.

Criticism 2

Although not specifically stated by Demarais and Strickland (2010), their references to Kroll and Koerth (1998) infer we had a preconceived expectation of outcome for the study presented in Koerth and Kroll (2008). To the contrary, Kroll and Koerth (1998:89) stated the following: "As noted earlier, no issue has created more controversy than the culling of spikes. Unfortunately, we still do not have the definitive answer." Our statement was based on experience and refereed literature available at that time. The Kroll and Koerth (1998) manuscript was in part the basis for designing the experiment leading to the Koerth and Kroll (2008) study.

Although complex, the primary criticism of Demarais and Strickland (2010) can be reduced to one point: did we bias our study by allowing hunters to harvest some males during the study? In designing our experiment, we considered potential sources of bias. There is more than one type of bias including selection bias, measurement bias, and treatment bias. Our study involved 12 study areas (ranches) in 5 south Texas counties. Our research was conducted under free-living conditions subject to hunting rather than a penned situation. Demarais and Strickland (2010:196) acknowledged in such cases, "…private landowners may have selective harvest programs that are beyond the control of researchers." There were no specific culling criteria in our study because our objective was not to determine if culling can improve overall antler quality. For our purposes, having been visibly marked with an ear tag created no preferential treatment for any deer. Each landowner, manager, or hunter decided independently about killing specific animals. We did not question each legal harvest to determine if the animal had been killed because the hunter perceived the animal as inferior or as a trophy.

Perhaps part of the misunderstanding is from use of the term cull in our original manuscript. From our perspective a culled animal was one that was killed and permanently removed from the population. It was not meant to imply the animal was removed in a preconceived manner to affect the overall genetics of the subsequent population.

Demarais and Strickland (2010) also made several assumptions regarding our study in their modeling analysis, including the following:

1. "…animals were culled based on their relatively smaller antler size…" (194).
2. "If a greater percentage of one treatment was culled than the other, then the resultant sample would not have been random, and the resultant tagged deer population left for future sampling would no longer be an unbiased sample of the deer population" (194).

We did not discuss nor list any culling criteria in Koerth and Kroll (2008). We only stated some of the deer had been killed at $\geq$2.5 years of age during the study. If there had been selection bias by hunters, it would be appropriate to question whether or not there was a measurement bias in our study. Therefore, we examined our data to determine if number of yearling points was a good predictor of antler size of animals killed by legal hunters and if hunters appeared to disproportionately select against yearlings in subsequent years if those animals represented the smaller antler point group (Koerth and Kroll 2008).

In Koerth and Kroll (2008) we compared antler measurements of harvested deer by age class using linear regression to determine if number of points on a male's first set of antlers was a good predictor of gross B&C score at harvest. The dependent variable was gross B&C score and the independent variable was number of antler points on the animal's first set of antlers. Linear regression analysis indicated the number of points on yearling males accounted for only a small percentage of variation in gross B&C score for those males regardless of their age when killed ($r^2 = 0.211$ at 2.5 yr of age, $r^2 = 0.093$ at 3.5 yr, $r^2 = 0.012$ at 4.5 yr, and $r^2 = 0.116$ at $\geq$5.5 yr; Koerth and Kroll 2008). Antler size at harvest was poorly related to number of antler points on their first set of antlers, indicating most of the final antler score must have been accounted for by other factors.

The regression analysis revealed no apparent relationship in the number of antler points on a male's first set of antlers and antler size at harvest. Assuming antler size was a primary reason hunters elected to kill an animal, they did not appear to be selectively killing animals that started with few antler points on their first set of antlers.

To further determine if hunter bias may have affected the overall population in our study, we used chi-square analysis to determine if the number of males killed by hunters in the

Table 1. Number of white-tailed deer males marked and number killed by age and yearling point class in south Texas, USA, from 1999 to 2007.

No. of yearling points	*N*	2.5 yr old	3.5 yr old	4.5 yr old	≥5.5 yr old
≤3 points	670	31	24	20	10
≥4 points	648	21	21	15	19

2 antler point classes (≤3 points and ≥4 points) differed from the number of each antler point class marked and available in the population. Analysis of the 1,318 yearling deer tagged and the number subsequently killed by hunters at various ages indicated no differential harvest was evident ($\chi^2_1 = 1.324$, $P = 0.250$; $\chi^2_1 = 0.077$, $P = 0.782$; $\chi^2_1 = 0.444$, $P = 0.505$; and $\chi^2_1 = 0.060$, $P = 0.151$ for animals killed at 2.5 yr old, 3.5 yr old, 4.5 yr old, and ≥5.5 yr old, respectively; Table 1). At each age class, yearling males that started with ≤3 or ≥4 antler points on their first set of antlers were removed by hunters from the population matching their occurrence. Therefore, an equal percentage of each antler class survived to be available for sampling in subsequent years. Hence, the resultant tagged population did represent an unbiased sample of the deer population.

Finally, we examined if gross B&C score differed between males killed by hunters and males captured and released back into the population. Aerial capture can be assumed to be a more random sample of the population than hunting because there is no individual decision made to permanently remove an animal from the population. Males were captured as they were found by the helicopter capture crew. Gross B&C score did not differ for any age class between males captured and released and those killed by hunters (Table 2). Hunters did not appear to be selectively killing animals with the smallest antlers at any age.

In addition, Demarais and Strickland (2010) showed a significant proportion of culled animals in their simulation population came from animals represented by the ≤3 point category at 2.5 years of age. They apparently assumed no difference between their experimental data set and data from our study in southern Texas. If the same occurred with our population, they concluded killing of deer by hunters would have significantly biased the composition of the subsequent population. However, chi-square analysis indicated no significant difference in the number of males killed by hunters in our study between the ≤3 or ≥4 point categories at 2.5 years of age ($\chi^2_1 = 2.597$, $P = 0.086$; Table 3). Criticism of bias by hunters removing some males during the study appears to be unwarranted. It also may underscore the difficulty in directly extrapolating results from strictly confined animals to wild populations.

Because these were free-living animals subject to hunting, the potential antler score of animals killed before they reached maturity will never be known. Also, animals can die at all ages from causes other than hunting, and how their loss affects the resultant population will never be known. However, similar conditions occur with penned animals. All animals do not survive to maturity even in confined situations, and researchers are relegated to measuring only the ones that do.

We agree antler metrics other than number of points may more accurately represent antler size. We too have found yearling males with larger antlers and few antler points that would score higher gross B&C than smaller antlers with more points. This possible disparity between number of antler points and antler size may be one of the reasons the number of antler points on yearling males is a poor predictor of antler size at maturity. However, we used number of antler points because that was the metric used in the original studies and has been at the forefront of the contention since that time (Armstrong et al. 1995, Jacobson 1998). Also, number of antler points is the most commonly used antler restriction by states (Adams et al. 2009). Apparently many state wildlife agencies feel number of points is a more practical guide for hunters who may not be well versed in or able to estimate continuous variables such as antler mass or B&C score proposed by Demarais and Strickland (2010). If we expect hunters and managers to follow recommendations derived from wildlife research, then results based on variables readily used even by nonprofessionals should not be discounted lightly.

Our ≤3 point category included yearling males that had ≥3 antler points on one side and an unbranched antler on the other so our sample would conform to the current antler restrictions used in Texas. Under those restrictions the number of points on each antler was a determining criterion for legal harvest. Demarais and Strickland (2010) are in error when they state this criterion had only been proposed. The antler point restrictions were in full effect in all or part of 61 counties at the time of our research and have since been expanded to an additional 52 counties (Texas Parks and Wildlife Departmen 2009). However, the particular antler conformation in question appears to be unusual, at least by our sample, where only 3 animals met this condition. It is difficult to imagine inclusion of these animals would confound subsequent analyses.

Criticisms 3 and 4

We fully acknowledge the results of any geographically restricted study, even when distributed across 5 counties, should not be extended over the range of a species. This criticism involved objections to 3 aspects of our study. First, 11 of 12 study areas were high-fenced, with only one low-fenced study area. Second, supplemental feed was available on the study areas. Third, males were removed through hunting during the study. We agree that high-fenced properties represent a special management situation, and we should be careful about extrapolating results to non-fenced properties. We also agree that supplemental feeding, although commonly practiced where legal, may be a special management condition in other regions. However, we assert that landowners who have high-fenced property have more

Table 2. Mean (±SE) Boone and Crockett score[a] of white-tailed deer males captured or killed by age in south Texas, USA, from 1999 to 2007.

Methods and measures	2.5 yr old			3.5 yr old			4.5 yr old			≥5.5 yr old		
	N	$\bar{x}$	SE	*N*	$\bar{x}$	SE	*N*	$\bar{x}$	SE	*N*	$\bar{x}$	SE
Retrieval method												
Captured	297	216.7	2.39	129	277.6	3.50	55	310.1	5.87	27	352.3	7.77
Killed	49	207.3	3.76	45	272.8	3.96	35	312.7	4.88	29	359.4	6.76
Statistical measure												
Total	346			174			90			56		
P-value[b]		0.119			0.462			0.755			0.502	

[a] Boone and Crockett score converted from Imperial to metric for publication.
[b] *t*-test.

control over deer herds than non–high-fenced landowners. Emigration and immigration of young males can frustrate attempts to manipulate the genetics of unfenced herds through culling of young males. As with most published reports, we must rely on the discretion of readers to determine if the conclusions and implications of a study apply in their situations.

DESIGN AND ANALYSIS ISSUES IN THE DEMARAIS AND STRICKLAND (2010) MODEL

Demarais and Strickland (2010) and Strickland et al. (2001) used similar models to derive management conclusions using 3 sources of data. In the earlier publication, Strickland et al. (2001:510) stated data for model development included "…antler records from 220 known-aged males from captive populations in the southern U.S. for the model population…" Later, Demarais and Strickland (2010:194) stated the following: "We simulated potential biases in Koerth and Kroll's (2008) methods using antler data from 220 males reared in research pens at Mississippi State University, University of Georgia, and Kerr Wildlife Management Area, Texas, USA (Strickland et al. 2001)." In neither publication do the authors provide the sample sizes for each geographic area, any information regarding the provenance of these data, or the detailed methods used in model design. However, the selection and quality of data included in a model is paramount to assessing the validity, no matter the professed sophistication of methodologies (cf., Romesburg 1981). Concerns expressed by Demarais and Strickland (2010) for our research results included unstated sample sizes, subsampling of individuals (selection bias), lack of consideration for year or cohort and nutrition of research animals, and selective removal of individuals. We assert the same considerations are inherent to their modeling efforts.

Model data for Demarais and Strickland (2010) came from confined breeding programs in Georgia, Mississippi, and Texas. Several significant assumptions were made in their modeling; most notable were that data from a wild population in our study were similar to those from confined populations used in the model and that males removed by hunting in our study represented only individuals with the smallest antlers. Our above analyses indicate neither assumption is correct. Furthermore, although not stated, using data developed at the Texas KWMA and Mississippi State University is problematic for the following reasons:

1. In an independent evaluation, Waldron (1998) concluded neither the Texas KWMA nor Mississippi State University studies were ideal for genetic parameter estimation.
2. Waldron (1998) also concluded heritability estimates may not be the same for different populations and origins used in such studies.
3. Lukefahr (1997), in a review of the methodologies used in the Texas KWMA study, noted 70% of the animals used in the Williams et al. (1994) analysis were inbred and many of the deer were related to one male.

Further, the Texas KWMA experimental design suggests significant selection bias for study animals including the following:

1. Individuals were selected for the study at 3.5 years old, after antler quality was known (a posteriori design).
2. Some individuals were added and some deleted from the 2 experimental groups (spike- vs. fork-antlered males) during the study.
3. Subsequent progeny from the fork-antlered line used for later genetics research were produced from a single male.
4. Texas Parks and Wildlife Department has acknowledged experimental design issues may exist (Mitch Lockwood, Texas Parks and Wildlife Department, personal communication).
5. To our knowledge no peer-reviewed, published study to date has been able to replicate the results of the Texas KWMA study; however, replication of results is the cornerstone to acquiring reliable knowledge for any scientific discipline.

We are unaware if similar problems exist for populations from Georgia and Mississippi, but inclusion of data with known problems in a broad geographic model is questionable. Inherent to developing a model that produces reliable results is understanding the data used in its development.

Table 3. Number of 2.5-year-old white-tailed deer males killed by hunters by point class in south Texas, USA, from 1999 to 2007.

No. of yearling points	Marked	Killed	Survived
≤3 points	170	31	145
≥4 points	176	18	152

RECOMMENDATIONS

The issues involved in culling of immature white-tailed deer are complex and transcend biological, political, and sociological aspects of wildlife management. Unfortunately, we feel neither the quality of science nor amount of reliable knowledge related to these issues will change firm opinions. It is unfortunate that a great deal of time and money has been spent studying the role of genetics on antler quality in wild populations. Most biologists agree the components of good deer management are nutrition, age, proper harvest, and genetics. Of these, we believe the first 3 offer the greatest return from management efforts. We feel the focus on culling and genetic manipulation has created a quick-fix mentality among landowners and hunters where it does not exist.

ACKNOWLEDGMENTS

We thank ranch owners and managers L. Wheeler, M. Berry, R. Herdell, A. Schatte, A. Allen, P. Dailey, A. Stuart, B. Powell, B. Mueller, the Dilworth family, J. Kalinda, and D. Moore for their help and support. We also thank the helicopter pilots, the capture crews, and the many people who donated their time to help handle animals.

LITERATURE CITED

Adams, K., J. Hamilton, and M. Ross. 2009. QDMA's whitetail report 2009. Quality Deer Management Association, Bogart, Georgia, USA.

Arkansas Game and Fish Commission. 2009. Deer hunting in Arkansas. <http://www.agfc.com/hunting/deer/seasondates-deer.aspx>. Accessed 17 Apr 2009.

Armstrong, B., D. Harmel, B. Young, and F. Harwell. 1995. The management of spike bucks in a white-tailed deer population. Texas Parks and Wildlife Department PWD LF W7100-247, Austin, TX, USA.

Bullock, J. E., D. C. Guynn, Jr., and H. A. Jacobson. 1995. Evaluating the plan. Pages 66–77 *in* K. V. Miller and R. L. Marchinton, editors. Quality whitetails: the why and how of quality deer management. Stackpole, Mechanicsburg, Pennsylvania, USA.

Demarais, S. 1998. Managing for antler production: understanding the age-nutrition-genetics interaction. Pages 33–36 *in* K. A. Cearley and D. Rollins, editors. The role of genetics in white-tailed deer management. Second edition. Texas A&M University, College Station, USA.

Demarais, S., and B. K. Strickland. 2010. White-tailed deer antler research: a critique of design and analysis methodology. Journal of Wildlife Management 74:193–197.

Demarais, S., B. K. Strickland, and L. E. Castle. 2005. Antler regulation effects on white-tailed deer on Mississippi public hunting areas. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 59:1–9.

Duda, M. D., S. J. Bissell, and K. C. Young. 1998. Wildlife and the American mind: public opinion on and attitudes toward fish and wildlife management. Responsive Management, Harrisonburg, Virginia, USA.

Hamilton, J., W. M. Knox, and D. C. Guynn. 1995. How quality deer management works. Pages 7–18 *in* K. V. Miller and R. L. Marchinton, editors. Quality whitetails: the why and how of quality deer management. Stackpole, Mechanicsburg, Pennsylvania, USA.

Jacobson, H. A. 1998. Culling as a management practice for white-tailed deer: the dark side. Pages 93–98 *in* K. A. Cearley and D. Rollins, editors. The role of genetics in white-tailed deer management. Second edition. Texas A&M University, College Station, USA.

Koerth, B. H., and J. C. Kroll. 2008. Juvenile-to-adult antler development in white-tailed deer in south Texas. Journal of Wildlife Management 72:1109–1113.

Kroll, J. C., and B. H. Koerth. 1998. To cull or not to cull: a really good question! Pages 85–92 *in* K. A. Cearley and D. Rollins, editors. The role of genetics in white-tailed deer management. Second edition. Texas A&M University, College Station, USA.

Lukefahr, S. D. 1997. Genetic and environmental parameters for antler development traits in white-tailed deer using an animal model. Final report. Texas Parks and Wildlife Contract 386–0692, Kingsville, TX, USA.

Lukefahr, S. D., and H. A. Jacobson. 1998. Variance component analysis and heritability of antler traits in white-tailed deer. Journal of Wildlife Management 62:262–268.

Michigan Department of Natural Resources. 2009. Antler restriction regulations. <http://www.michigan.gov/dnr/0,1607,7-153-10363_10856_10905-194008--,00.html>. Accessed 17 Apr 2009.

Mississippi Department of Wildlife, Fisheries and Parks. 2009. 2008–2009 Deer seasons. <http://mdwfp.com/Level2/Wildlife/Game/Deer/Articles.asp?article=366>. Accessed 17 Apr 2009.

Ott, J. R., J. T. Baccus, S. W. Roberts, D. E. Harmel, E. Fuchs, and W. E. Armstrong. 1998. The comparative performance of spike- and fork-antlered yearling white-tailed deer: the basis for selection. Pages 22–32 *in* K. A. Cearley and D. Rollins, editors. The role of genetics in white-tailed deer management. Second edition. Texas A&M University, College Station, USA.

Pennsylvania Game Commission. 2009. New antler restrictions. Questions & answers. <http://www.pgc.state.pa.us/pgc/cwp/view.asp?a=465&q=151294>. Accessed 20 Apr 2009.

Romesburg, H. C. 1981. Wildlife science: gaining reliable knowledge. Journal of Wildlife Management. 45:293–313.

Strickland, B. K., S. Demarais, L. E. Castle, J. W. Lipe, W. H. Lunceford, H. A. Jacobson, D. Frels, and K. V. Miller. 2001. Effects of selective-harvest strategies on white-tailed deer antler size. Wildlife Society Bulletin 29:509–520.

Texas Parks and Wildlife Department. 2006. 2006–2007 Texas fishing and hunting regulations summary. Special antler restrictions. <http://www.tpwd.state.tx.us/publications/annual/hunt/game/index.phtml#special>. Accessed 7 May 2007.

Texas Parks and Wildlife Department. 2009. Commission adopts sweeping changes to deer regulations.<http://www.tpwd.state.tx.us/newsmedia/releases/?req=20090326d&nrtype=all&nrspan=2009&nrsearch=>. Accessed 21 Apr 2009.

Waldron, D. F. 1998. A critical evaluation of studies on the genetics of antler traits of white-tailed deer. Pages 72–79 *in* K. A. Cearley and D. Rollins, editors. The role of genetics in white-tailed deer management. Second edition. Texas A&M University, College Station, USA.

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

Associate Editor: Chamberlain.