Mass Estimation of White-tailed Deer in Southern Texas

Mickey W. Hellickson,[1] *D. B. Warnell School of Forest Resources, The University of Georgia, Athens, GA 30602-2152*

Karl V. Miller, *D. B. Warnell School of Forest Resources, The University of Georgia, Athens, GA 30602-2152*

Charles A. DeYoung, *Caesar Kleberg Wildlife Research Institute, Texas A&M University-Kingsville, Kingsville, TX 78363*

R. Larry Marchinton, *D. B. Warnell School of Forest Resources, The University of Georgia, Athens, GA 30602-2152*

Stuart W. Stedman, *Wesley West Cattle Company, P.O. Box 7, Houston, TX 77001*

Robert E. Hall,[2] *Caesar Kleberg Wildlife Research Institute, Campus Box 218, Texas A&M University-Kingsville, TX 78363*

Abstract: Predictive equations based on various body measurements have provided wildlife managers with practical and reliable estimates of deer mass, but have not been reported for white-tailed deer (*Odocoileus virginianus*) in the Western Rio Grande Plain region of Texas, nor for male white-tailed deer in Texas. To address this need, we assessed relationships among live mass and dressed mass, chest girth, shoulder height, hoof length and width, and gross Boone and Crockett Club (BCC) score. Regression analyses indicated live mass of mature (>5.5 years old) males can be predicted with a model based on dressed mass (R^2= 0.883). Chest girth (R^2 = 0.486) and shoulder height (R^2 = 0.397) provided less reliable estimates, whereas gross BCC score and age provided poor estimates (R^2 < 0.19). Female fawn and yearling live mass can be predicted with models based on dressed mass (R^2 = 0.962), hoof length (R^2 = 0.898), shoulder height (R^2 = 0.822), and chest girth (R^2 = 0.772), whereas only dressed mass provided an accurate prediction of live mass (R^2 = 0.818) for adult females. Wildlife managers can use these equations to accurately estimate live mass of live-captured or harvested white-tailed deer by sex and age class in the Western Rio Grande Plain region of Texas.

Key words: mass estimation, white-tailed deer, *Odocoileus virginianus*

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 62:35–39

Knowledge of body mass is important to wildlife research and management (Talbot and McCulloch 1965). Live mass is a useful predictor of fecundity in barren-ground caribou (*Rangifer tarandus groenlandicus*; Cameron and Ver Hoef 1994) and juvenile survival in bighorn sheep (*Ovis canadensis*; Festa-Bianchet et al. 1997). Predictive equations based on chest girth or partial body mass have been used to provide simple, reliable estimates of body mass in several large mammals (Talbot and McCulloch 1965, Rideout and Worthen 1975). The low cost and convenience of mass equations makes them practical when body mass is difficult to obtain in the field (Smart et al. 1973, Millspaugh and Brundige 1996) and when it is necessary to release live-trapped deer as quickly as possible (Weckerly et al. 1987).

Previous researchers have examined relationships between body mass and chest girth for bison (*Bison bison*; Kelsall et al. 1978), Rocky Mountain elk (*Cervus elaphus canadensis*; Millspaugh and Brundige 1996, Cook et al. 2003), mountain goat (*Oreamnos americanus*; Rideout and Worthen 1975), barren ground caribou (*Rangifer tarandus groenlandicus*; McEwan and Wood 1966), black bear (*Ursus americanus*; Payne 1976), grizzly bear (*U. arctos*; Nagy et al. 1984), exotic deer in Texas (Osborn et al. 1995), Alpine ibex (*Capra ibex*; Bassano et al. 2003) and several east African ungulates and domestic livestock (McCulloch and Talbot 1965, Talbot and McCulloch 1965). All of these studies concluded that chest girth was sufficiently correlated to provide an accurate estimate of live mass.

Regression equations relating body mass to chest girth have been developed for white-tailed deer (*Odocoileus virginianus*) in Virginia (Smart et al. 1973), Illinois (Roseberry and Klimstra 1970), South Carolina (Urbston et al. 1976), and Tennessee (Weckerly et al. 1987). However, they have not been reported for deer in the Western Rio Grande Plains region of Texas. The only Texas study took place in the Edwards Plateau region and examined only females (Osborn et al. 1995). Average live mass for these females was 34.4 kg, an amount considerably less than the 49.1 kg we report for adult females from the Western Rio Grande Plains. Equations based on smaller-bodied deer from the Edwards Plateau region therefore, were likely less reliable for deer in the Western Rio Grande Plains region.

1. Present address: King Ranch Production Office, P.O. Box 1090, Kingsville, Texas 78364-1090
2. Present address: Whitewing Farms, P.O. Box 692, Crystal City, TX 78839

Weckerly et al. (1987) examined relationships among body mass and age, sex, and season and reported variation among areas as close as 250 km. They concluded that use of regressions without regard to location and the conditions under which they were derived may not provide accurate results. In Mississippi, growth rates for body mass and an antler size index of deer vary across physiographic regions (Strickland and Demarais 2000). Similarly, Bandy et al. (1970) reported differences in growth rates within four races of black-tailed deer (*O. hemionus columbianus*). McCulloch and Talbot (1965) reported that statistical relationships were only valid for mass estimations when applied to populations that did not differ significantly from the population in which the regressions were developed.

Mass estimation equations have not been reported for male white-tailed deer (*O. v. texanus*) in Texas, although this information would be valuable to landowners who capture and transplant deer under the increasingly popular Texas Parks and Wildlife Department (TPWD) Trap, Transport, and Transplant permit program (TTT; TPWD 2008). Accurate body mass estimates could aid in determining whether or not to transplant individual deer and may aid in the selection of appropriate release sites. The number of TTT permits issued annually increased from 40 to 77 during 2004–2007 and the number of individual deer trapped increased from approximately 1700 to over 4500 (R. McGillicuddy TPWD, personal communication).

Our objectives were to test a variety of body and antler measures for estimating live mass of white-tailed deer in the Western Rio Grande Plains region of Texas, and to develop predictive equations of live mass for each sex and age class.

Methods

The study took place on the 18,020-ha Faith Ranch in Dimmit and Webb counties, Texas. The ranch is located in the Western Rio Grande Plains region. Annual mean minimum and maximum temperatures were 15 and 29 C, respectively, and annual mean precipitation was 54.6 cm. (Stevens and Arriaga 1985). The gently rolling terrain was dominated by guajillo (*Acacia berlandieri*), blackbrush (*A. rigidula*), guayacan (*Porlieria angustifolia*), and honey mesquite (*Prosopis glandulosa*).

Two yearling males, 65 males >4.5 years old, 3 female fawns, 11 yearling females, and 74 females >2.5 years old were harvested during gun hunting seasons from 15 November-4 February 1993–97. All deer were aged using tooth replacement and wear techniques (Severinghaus 1949). Main beam length, basal circumference, and tine length were measured on each antler and combined with inside antler spread to estimate gross BCC score according to Nesbitt and Wright (1997). Chest girth was measured immediately behind the front shoulder. Stomach girth was measured at a point half the distance between the distal portion of the front shoulder and the front of the thigh. Both girth measurements were taken immediately after harvest with deer unstretched and on their sides. The tape was snugged to a moderate and uniform tightness for all circumference measurements. Head length was measured from the highest point of the sagittal crest to the proximate point of the nose pad. Forehead width was measured at the furthest point between the ridges above the eye orbit. Live mass included body mass minus blood loss from the gunshot wound. Dressed mass included body mass after body cavity contents were removed. All mass measurements were to the nearest 0.45 kg using a spring scale. A steel tape was used and all measurements were along body curves and to the nearest 0.32 cm.

An additional 50 females were harvested from 16 March-18 April 1994 under scientific permit (SPR-1090-310) from the Texas Parks and Wildlife Department. Measurements included live mass, dressed mass, chest girth, shoulder height, and front leg hoof length and width. Hoof lengths and widths were measured to the nearest 0.32 cm using a steel tape and all other measurements followed techniques previously described for males.

Statistical analyses were performed using SAS (SAS 1987). One and two-way analysis of variance (ANOVA), *F*-tests, linear contrasts, and Tukey's studentized range test were used to test for significant differences among year, period of the breeding season, and age for each sex. Breeding seasons were established based on reproductive data collected from 50 females during March-April 1994 (Ruthven et al. 1995). Seasons were: pre-rut (15 Nov-7 Dec), when 6% of harvested females were successfully impregnated; rut peak (8 Dec-4 Jan), when 86% were impregnated; post-rut (5 Jan-25 Jan), when 8% were impregnated; and non-rut (26 Jan-20 Apr), when no females were impregnated.

Additional statistical analyses included least squares regression to develop linear equations describing the above relationships. Multiple regression analyses were used to develop predictive models for estimating mass using the above measures. Model selection was based upon R^2 value.

Results

Males

Very few young and middle-aged males were sampled because restrictive harvest guidelines limited the harvest to males thought to be >5.5 years old. Therefore, mass estimation analyses were limited to males >5.5 years old because only four males between 1.5 and 4.5 years old were harvested and weighed. Live mass for males (>5.5 years) did not vary by breeding season ($P > 0.25$), year ($P > 0.63$), or age ($P > 0.21$) and were combined in analyses. Least squares regression indicated the variables with highest coefficient of determination (R^2) values for providing an estimate of live mass were dressed mass, chest girth, and shoulder height (Table 1). The variables gross BCC score and age provided poor estimates ($R^2 <$ 0.19).

Multiple regression analyses indicated the best model (highest R^2 value) for predicting live mass of mature males included dressed mass and shoulder height ($R^2 = 0.897$) for a two-variable predictive model. The addition of a third or fourth variable did not increase predictive power. However, for purposes of estimating live mass of captured deer to be released, we deleted dressed mass in further analyses (Table 2). The best model without dressed mass was chest girth and shoulder height ($R^2 = 0.575$) for a two-variable model. Additional variables were not significant (Table 2).

Table 1. Linear regression equations developed to estimate live mass for white-tailed deer at the Faith Ranch, Dimmit and Webb counties, Texas, 1993–1997.

				Live mass (kg)			
Sex	**Age**	**Season**	***n***	**0 ± SE**	***R*²**	***P*-value**	**Equation**[a]
Male	5.5+	Fall–Winter	42	79.2 1.1	0.883	0.001	Y = 16.29 + 0.98(DM)
			35		0.486	0.001	Y = −14.51 + 0.97(CH)
			35		0.397	0.001	Y = −31.29 + 1.18(SH)
Female	0.5–1.5	Fall–Spring	10	38.4 1.7	0.962	0.001	Y = 1.61 + 1.22(DM)
			10		0.898	0.001	Y = −22.33 + 8.73(HL)
			10		0.822	0.001	Y = −34.94 + 0.92(SH)
			10		0.772	0.001	Y = −22.38 + 0.83(CH)
Female	2.5+	Fall–Spring	70	51.6 0.6	0.818	0.001	Y = 6.11 + 1.16(DM)
			40		0.460	0.001	Y = −24.71 + 0.95(CH)

a. Y = live mass, DM = dressed mass (kg), CH = chest girth (cm), SH = shoulder height (cm), HW = hoof width (cm), and HL = hoof length (cm).

Table 2. Multiple regression models (Y = B0 + B1X1 + B2X2 + B3X3) for predicting live mass of male white-tailed deer at the Faith Ranch, Dimmit and Webb counties, Texas, 1993–1997, using variables that could be measured on live animals before release.

Dependent variable (Y)	Independent variables (X,)	Coefficients (B_i)	R^2	Coefficient		*n*
				SE	*P*-value	
Mass	Intercept	−50.7	0.575	21.5	0.025	34
	Chest girth	0.67		0.22	0.005	
	Shoulder height	0.69		0.28	0.019	
Mass	Intercept	−29.3	0.609	25.1	0.252	34
	Age	−1.02		0.66	0.131	
	Shoulder height	0.48		0.30	0.127	
	Chest girth	0.73		0.22	0.002	
Mass	Intercept	−30.0	0.609	26.7	0.270	32
	Chest girth	0.72		0.24	0.006	
	Shoulder height	0.48		0.31	0.136	
	Gross BCC score	0.01		0.07	0.930	
	Age	−1.00		0.71	0.172	

Table 3. Multiple regression models (Y = B0 + B1X1 + B2X2 + B3X3) for predicting live mass of adult female white-tailed deer at the Faith Ranch, Dimmit and Webb counties, Texas, 1994–97.

Dependent variable (Y)	Independent variables (X_i)	Coefficients (B_i)	R^2	Coefficient		*n*
				SE	*P*-value	
Mass	Intercept	−118.30	0.777	18.20	0.0001	50
	Hoof width	49.83		9.95	0.0001	
	Chest girth	4.80		0.70	0.0001	
Mass	Intercept	−43.60	0.801	8.98	0.0001	50
	Hoof width	8.68		1.70	0.0001	
	Age	0.61		0.26	0.0001	
	Chest girth	0.70		0.14	0.0232	
Mass	Intercept	−48.80	0.809	9.64	0.0001	50
	Hoof width	8.90		1.69	0.0001	
	Shoulder height	0.16		0.11	0.170	
	Chest girth	0.60		0.15	0.0004	
	Age	0.63		0.26	0.019	

Females

Live mass for females did not vary by breeding season ($P >$ 0.32) or year ($P > 0.43$) and no breeding season by year interaction was found (P > 0.41), so data were combined in analyses. Live mass varied by age ($F = 8.15$, $P = 0.0001$) with live mass of fawns and yearlings different from females >2.5 years old ($F = 57.7$, P = 0.0001). Tukey's studentized range test revealed that live mass of fawns was different from all other ages except yearlings, which were different from females >2.5 years old. No differences were found for females >3.5 years old. Due to age differences, females were separated into two age classes (0.5–1.5 and 2.5+).

Least squares regression indicated best individual variables for providing an estimate of live mass for females aged 0.5–1.5 years were dressed mass, hoof length, shoulder height, and chest girth with R^2 values of 0.962, 0.898, 0.822, and 0.772, respectively (Table 1). Best variables for females >2.5 years old were dressed mass and chest girth with R^2 values of 0.818 and 0.460 respectively (Table 1). Shoulder height, hoof length, and age provided poor estimates (R^2 < 0.22).

Multiple regression analyses indicated the best models for predicting live mass of females included dressed mass and hoof width ($R^2 = 0.944$) for a two-variable model; dressed mass, hoof width, and age ($R^2 = 0.951$) for a three-variable model; and dressed mass, hoof length and width, and age ($R^2 = 0.953$) for a four-variable model. Best models not including dressed mass that would be useful for evaluating live animals, included the variables hoof width and chest girth ($R^2 = 0.777$) for a two-variable model; hoof width, age, and chest girth ($R^2 = 0.801$) for a three-variable model; and hoof width, shoulder height, chest girth, and age ($R^2 = 0.809$) for a four-variable model (Table 3).

Repeatability of Measurements

Harvested males that had been previously captured (12–15 months earlier) by helicopter-drive net (Beasom et al. 1980) or net gun (DeYoung 1988) techniques and measured ($N = 20$), allowed us to test accuracy of chest girth and shoulder height measurements. Chest girth and shoulder height measurements increased a mean of 2.5 and 1.6 cm, respectively among capture and harvest. It was thought that neither measure should decrease as males increased in age. However, chest girth decreased for 25% of the sample and shoulder height decreased for 55% of the sample, indicating repeatability of measuring these indices may be poor. An additional 9 males were harvested or recaptured 24–30 months later. Chest girth and shoulder height increased an average of 3.3 and 1.7 cm for these males, but decreased for 22% of the sample for each measure.

Discussion

Suitability of linear models for predicting live mass from dressed mass and chest girth for white-tailed deer in the Western Rio Grande Plains region of Texas agrees with data reported for deer in the southeastern United States (Smart et al. 1973, Urbston et al. 1976, Weckerly et al. 1987) and for female deer in central Texas (Osborn et al. 1995) with standard errors similar to those previously reported.

Analyses revealed the need for separate mass estimation equations among age classes of females, but not between years and periods of the breeding season. Not enough data were available to determine if age class differences occurred for males. Additional variables found suitable for providing estimates of live mass, as determined by linear regression, included shoulder height for mature males, hoof width for adult females, and shoulder height, hoof width, and hoof length for fawn and yearling females. Multiple regression indicated that chest girth combined with shoulder height increased accuracy of live mass estimates for mature males. Chest girth combined with hoof width increased accuracy for females. The predictive equations presented here can be used to estimate live mass of live-captured or harvested white-tailed deer by sex and age class in the Western Rio Grande Plain region of Texas.

Acknowledgments

We thank the numerous individuals who assisted with data collection. Research was supported by the Rob and Bessie Welder Wildlife Foundation, Neva and Wesley West Foundation, Caesar Kleberg Wildlife Research Institute, Texas A&M

University-Kingsville, and the D. B. Warnell School of Forestry and Natural Resources of The University of Georgia.

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