Using Mandibular Tooth Row Length to Age Yearling White-Tailed Deer

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Abstract

*Using current methods of age determination, white-tailed deer (*Odocoileus virginianus*) from the same cohort are classified as 1.5-year-old deer when actual age may vary by 6 or more months. We measured mandibular tooth row length (mm) on mandible impressions of 41 (23 males and 18 females) known-age captive white-tailed deer to develop an aging model that would estimate age in days. To test the model, each month from 12 to 24 months, we measured dentitions of 34 (19 males, 15 females) known-age captive white-tailed deer. We found that mandibular tooth row length was a strong predictor of age for both males ($r^2 = 0.93$; $P \leq 0.0001$) and females ($r^2 = 0.92$; $P \leq 0.0001$). For males and females, respectively, the equations that predicted age (days) were $\ln(\text{age}) = -4.34 + 2.45 \ln(\text{mandibular tooth row length in mm})$ and $\ln(\text{age}) = -4.62 + 2.54 \ln(\text{mandibular tooth row length in mm})$. The models predicted >50% of test jaws for males from 14 to 24 months and >60% of test jaws for females from 16–24 months within 7 days of actual age. Peak accuracy occurred at 18 months for males and 19–21 months of age for females. These models complement current aging methods and could be used by wildlife biologists in the field to age hunter-harvested deer ≤24 months.* (WILDLIFE SOCIETY BULLETIN 34(2):345–350; 2006)

Key words

aging, dentition length, Odocoileus virginianus*, technique, white-tailed deer, yearling.*

Wildlife managers need to know the age distribution within a white-tailed deer (*Odocoileus virginianus*) population. Age distribution is critical to understanding population dynamics and developing proper management strategies. Some methods used to determine age in deer include antler beam diameter (Lueth 1963), body mass (Lueth 1963), eye lens weight (Longhurst 1964, Connolly et al. 1969), molar tooth ratios (Robinette et al. 1957), cementum annuli (Low and Cowan 1963, Gilbert 1966, Ransom 1966, Rice 1980), and tooth wear and replacement (Severinghaus 1949).

An ideal aging technique would provide objective separation of age classes, be unaffected by physiological or nutritional variation of study animals, and be easy to perform (Larson and Taber 1980). Two techniques currently used that achieve these objectives include 1) cementum annuli and 2) tooth wear and replacement (Larson and Taber 1980). Both methods require trained personnel and reference collections. The drawbacks of the cementum annuli method are that 1) it is expensive to perform and 2) the method requires a laboratory setting to run samples. The drawback to using the second method is that tooth wear within a population of white-tailed deer from the same locale is not consistent and, therefore, not a precise predictor of age (Gee et al. 2002). The major advantages of aging deer using tooth eruption and replacement patterns rather than the cementum annuli method are 1) it is an easy method to teach, 2) inexpensive, and 3) less time-consuming than preparing teeth for cementum analysis.

Mitchell and Smith (1991) found close agreement between actual and estimated age when comparing cementum annuli and tooth wear and replacement on known-age white-tailed deer from the southeastern United States. Gee et al. (2002) reported that tooth wear and replacement allowed them to confidently categorize deer into fawn, yearling, and adult age classes but had inaccuracies after 2 years of age. However, since the tooth wear and replacement method is more cost effective for private and public management areas, many biologists in the southeastern United States continue to use this method despite documented imprecision in accuracy among older age classes (Gee et al. 2002).

For most of the United States, fawns are born within a 30- to 60-day period in early spring. However in some southeastern states, fawns may be born from May to November (Lueth 1955, 1967, Payne et al. 1966, Roberson and Dennett 1966, Jacobson et al. 1979) and in captive herds, as late as 6 December (M. K. Causey, Auburn University [retired], Auburn, Ala., USA, personal communication). This extended fawning season is evident at the Covington Management Area, Alabama, where fawns are first observed in June with peak fawn drop in late August and early September. Wildlife biologists at the Covington Management Area reported that a doe harvested on 22 November contained a fetus that was estimated to be within 2 weeks of birth (J. Powers, Alabama Department of Conservation and Natural Resources, Covington Wildlife Management Area, Andalusia, Ala., USA, personal communication).

Typically, all deer from the same cohort are lumped together as 1.5-year-olds and are considered to be the same age even though ages may differ by 6 months or more. This could contribute to variations in yearling body weights, which may range from 46 to 53 kg (Gray et al. 2002). Because body and antler growth are not correlated with exact age, managers have a difficult time making decisions involving selective harvest techniques (Gray et al. 2002). Deer biologists need tools that more precisely determine a deer's age within a given age class. The development of a technique that accurately ages white-tailed deer ≤24 months of age would enhance white-tailed deer management in Alabama, Florida, Louisiana, Mississippi, Texas, and other areas that exhibit wide variability in fawning dates.

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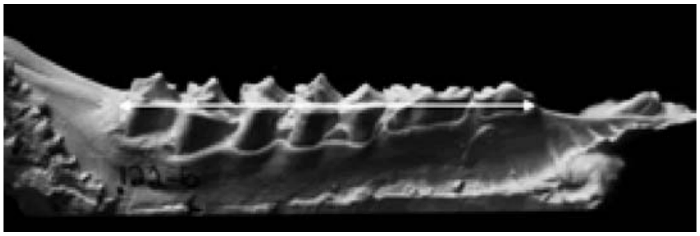

Figure 1. Dentition length of tooth row measured on dental impression from the first premolar to the last erupted molar.

To address this need, we developed a quantitative technique using mandibular tooth row length to age white-tailed deer ≤24 months from examination of known-age Alabama deer. We evaluated the regional application of this technique for use in other areas by comparing our results to known-age deer from Florida.

Methods

We raised and housed the white-tailed deer used to develop aging models at the Auburn University White-tailed Deer Research Facility in Auburn, Lee County, Alabama. All animal handling was performed in a humane manner and was approved by the Auburn University Institutional Animal Care and Use Committee. We recorded the dentition patterns of 23 male and 18 female known-age fawns born in captivity between 1988 and 1990. Mandibular tooth row length from the first premolar to the last erupted molar was measured on dental impressions from 2–24 months of age (Fig. 1). Pine (*Pinus* spp.) and sweetgum (*Liquidambar styraciflua*) were predominant in the overstory of the enclosures where the deer where housed. We fed fawns a 25%± protein pelleted ration. Pelleted ration and water were available ad libitum in each enclosure. We sedated deer at the Alabama facility with Rompun® (Mobay, Shawnee, Kansas) intramuscularly using a Pneu-dart® (Pneu-Dart, Williamsport, Pennsylvania) dart gun. While deer were sedated, we took dental impressions from the lower right jaw (Clawson and Causey 1995). To revive the deer, we administered yohimbine hyrdochloride (Fisher Scientific, Pittsburgh, Pennsylvania). Mandibular tooth length data collected from white-tailed deer used in an independent study examining the eruption of the third molar were used to validate the aging methodology. We housed these deer in 2 enclosures at the Deer Research and Education Facility at Tyndall Air Force Base in Bay County, Florida. We examined 34 known-aged fawns (19 males, 15 females) monthly from 12 to 24 months of age between 1993 and 1997. Overstory vegetation in this facility was comprised of slash pine (*Pinus elliottii*) and live oak (*Quercus virginiana*). Although minimal, understory was dominated by saw palmetto (*Serenoa repens*), rosemary (*Ceratiola ericoides*), and prickly-pear cactus (*Opuntia* spp.). Deer in one enclosure were fed a 25% protein pelleted ration and in the other a 9% protein pelleted ration to test molar eruption. Both the pelleted feed and water were available ad libitum. Minimal vegetation and acorns were available as supplementation to the diet. We sedated deer at the Florida facility with a mixture of Telazol (Fort Dodge Laboratories, Fort Dodge, Iowa) and Rompun. To revive sedated deer, we administered Tolazine® (Lloyd Laboratories Products, Shenandoah, Iowa) intravenously as an antagonist. We constructed dental casts from dental impressions (Clawson and Causey 1995).

Table 1. Accuracy of model (model data collection 1989–1991) tested on male white-tailed deer from Fla., USA (test data collection 1993–1997). Percent of test animals that were correctly aged to within 1–7, 8–14, 15–28, and >28 days using the derived model.

	Days							
	1–7		8–14		15–28		>28	
Age	*n*	%	*n*	%	*n*	%	*n*	%
12	3	15.8	2	10.5	4	21.1	10	52.6
13	2	10.5	0	0.0	3	15.8	14	73.7
14	10	52.6	0	0.0	1	5.3	8	42.1
15	12	63.2	0	0.0	0	0.0	7	36.8
16	13	68.4	0	0.0	2	10.5	4	21.1
17	13	68.4	0	0.0	1	5.3	5	26.3
18	14	73.7	1	5.3	0	0.0	4	21.1
19	12	63.2	0	0.0	3	15.8	4	21.1
20	11	57.9	0	0.0	2	10.5	6	31.6
21	11	57.9	3	15.8	0	0.0	5	26.3
22	10	52.6	0	0.0	3	15.8	6	31.6
23	11	57.9	0	0.0	0	0.0	8	42.1
24	13	68.4	0	0.0	0	0.0	6	31.6

We used a small sample of known-age and established-age white-tailed deer from Severinghaus's (1949) research to check the model to determine whether it would be practical for regional or national use. Mandibular tooth row length was measured on the following jaws, specimen number and age respectively, for 4 male (#152 [18.5 months], #225 [7 months], #279 [6 months], #299 [12 months]) and 3 female (#128 [18 months], #173 [10.25 months], #298 [2 months]) deer (C. Dente, NYSDEC Bureau of Wildlife, Albany, New York, USA, personal communication). In addition, jaws that Severinghaus had marked with ages (5 males and 2 females) but were not included in Severinghaus (1949; Table 1) were tested.

We analyzed both the Alabama and Florida data sets separately with *t*-tests to determine whether gender influenced mandibular tooth row length. To address dietary concerns, we also used *t*-tests to determine whether differences in dietary protein (9% vs. 25%) influenced mandibular tooth row lengths for the male and female deer from Florida.

We used known-age Alabama deer to make the model separating mandibular tooth row measurements by gender. We plotted the predicted values of age (in months) against the residuals. This produced a distribution that violated homogeneity of variance. Because of this, the natural log of the predictive values of age (in months) was plotted against the residual and met the criteria. We used regression (PROC REG; SAS Institute 1985) to create an equation to predict age. The dependent variable was the natural log of the age of the deer (in days), and the independent variable was the natural log of the length of the tooth row (mm). Mass was added as a variable, but this did not improve the R-square value. Although we examined each tooth measurement on the incisors, premolars, and molars in this manner, we failed to produce a consistent linear pattern because teeth were erupting, being lost, and replaced at different ages. We tested the accuracy of the dentition-length aging model by comparing age estimated

Table 2. Accuracy of model (model data collection 1989–1991) tested on female white-tailed deer from Fla., USA (test data collection 1993–1997). Percent of test animals that were correctly aged to within 1–7, 8–14, 15–28, and >28 days using the derived model.

	Days							
	1–7		8–14		15–28		>28	
Age	*n*	%	*n*	%	*n*	%	*n*	%
12	8	53.3	1	6.7	5	33.3	1	6.7
13	6	40.0	0	0.0	3	20.0	6	40.0
14	3	20.0	0	0.0	4	26.7	8	53.3
15	7	46.7	0	0.0	0	0.0	8	53.3
16	9	60.0	0	0.0	0	0.0	6	40.0
17	12	80.0	0	0.0	0	0.0	3	20.0
18	10	66.7	3	20.0	1	6.7	1	6.7
19	14	93.3	0	0.0	0	0.0	1	6.7
20	13	86.7	1	6.7	0	0.0	1	6.7
21	14	93.3	0	0.0	0	0.0	1	6.7
22	12	80.0	2	13.3	0	0.0	1	6.7
23	12	80.0	0	0.0	1	6.7	2	13.3
24	13	86.7	0	0.0	1	6.7	1	6.7

from mandibular tooth row length with actual age using paired *t*-tests at each month of age to known-age Florida deer and Severinghaus (1949) jaws.

Results

We found that gender influenced dentition development for both the Alabama and Florida white-tailed deer (Figs. 2, 3). The mean mandibular tooth row length for males differed from females for the Alabama and Florida deer, respectively, for the 14, 15, 17, 18, 19 and 16, 17, 18, 23 age months ($P < 0.05$). The mean mandibular tooth row length differed for Florida males on the 2 diets for 16, 17, 20, 22, 23, and 24 age months ($P < 0.05$) with length greater for the male deer on the 25% protein diet.

Mandibular tooth row length was a strong predictor of age for both males ($r^2 = 0.93$; $P \leq 0.0001$) and females ($r^2 = 0.92$; $P \leq 0.0001$). We derived gender-specific models to predict age from mandibular tooth row length. The association between male age (days) and mandibular tooth row length (mm) was predicted by the following equation:

$$\ln(\text{age}) = -4.34 + 2.45 \ln(\text{mandibular tooth row length}),$$

where ln is the natural log of the variable indicated. The association between female age (days) and dentition length (mm) was predicted by the following equation:

$$\ln(\text{age}) = -4.62 + 2.54 \ln(\text{mandibular tooth row length}),$$

where ln is the natural log of the variable indicated.

For example, for a male deer jaw with a tooth row measurement of 50 mm, take the natural log of the mandibular tooth row length ($X = \ln 50 = 3.91$). Entering 3.91 in the above equation for males would result in a $\ln Y = 5.24$. Y (age of deer with tooth row length of 50 mm) $= e^{5.24} = 189$ days old.

Accuracy of the models varied with age and gender. The model for male deer (Table 1) predicted >50% of the test sample to within 7 days of the true age from 14–24 months of age. The peak of accuracy occurred at 18 months of age when 73.7% (14 of 19) of the deer were correctly aged to within 7 days. The female model achieved similar accuracy (Table 2). The greatest accuracy occurred from 19 to 21 months of age when >85% of the deer were aged to within 7 days. Over 60% of the yearling females from 16–24 months of age were aged to within 7 days. When the error associated with predicting deer age was >28 days, there was wide variability in the predictions (Table 3). The maximum error for male deer was 166 days, which occurred at 15 months of age, and the maximum error for female deer was 144 days, which occurred at 17 months of age.

When we tested Severinghaus's (1949) mandibular tooth row lengths, the model overestimated the age of the New York white-tailed deer. From Severinghaus (1949; Table 1), 1 6-month-old male fell within the 7-day range; 1 12-month-old male fell within the 28-day range, and 2 males (7 and 18.5 months old) went over 50 days. Three females (2, 10.25, and 18 months old) fell outside the 50-day range. For the additional New York jaws, 1 (19-months-old) of 5 males (1 3-month-old, 1 9-month-old, 2 18-month-olds, 1 19-month-old) fell within 14

Table 3. Mean, minimum, and maximum errors (in days) for Fla., USA, deer (test data collection 1993–1997), of predicted ages in which the estimated age was >28 days different from the actual age.

	Males					Females				
			Error (days)					Error (days)		
Month	% of sample	*n*	Mean	Min	Max	% of sample	*n*	Mean	Min	Max
12	52.6	10	54.9	39.0	98.8	6.7	1	49.88		
13	73.7	14	66.6	29.6	117.4	40.0	6	47.7	38.3	52.5
14	42.1	8	103.2	59.6	147.4	53.3	8	60.8	38.7	82.5
15	36.8	7	93.8	47.4	165.8	53.3	8	81.5	53.4	112.5
16	21.1	4	62.5	32.6	91.8	40.0	6	80.0	35.2	128.3
17	26.3	5	59.4	47.0	62.6	20.0	3	117.5	65.2	143.7
18	21.1	4	60.7	28.2	92.6	6.7	1	78.4		
19	21.1	4	78.5	58.2	122.6	6.7	1	91.3		
20	31.6	6	59.7	36.6	88.2	6.7	1	48.7		
21	31.6	5	59.2	30.6	101.4	6.7	1	40.0		
22	31.6	6	69.2	42.1	131.4	6.7	1	50.1		
23	42.1	8	69.4	34.0	108.8	13.3	2	49.4	39.1	59.8
24	31.6	6	95.5	44.5	120.6	6.7	1	89.9		

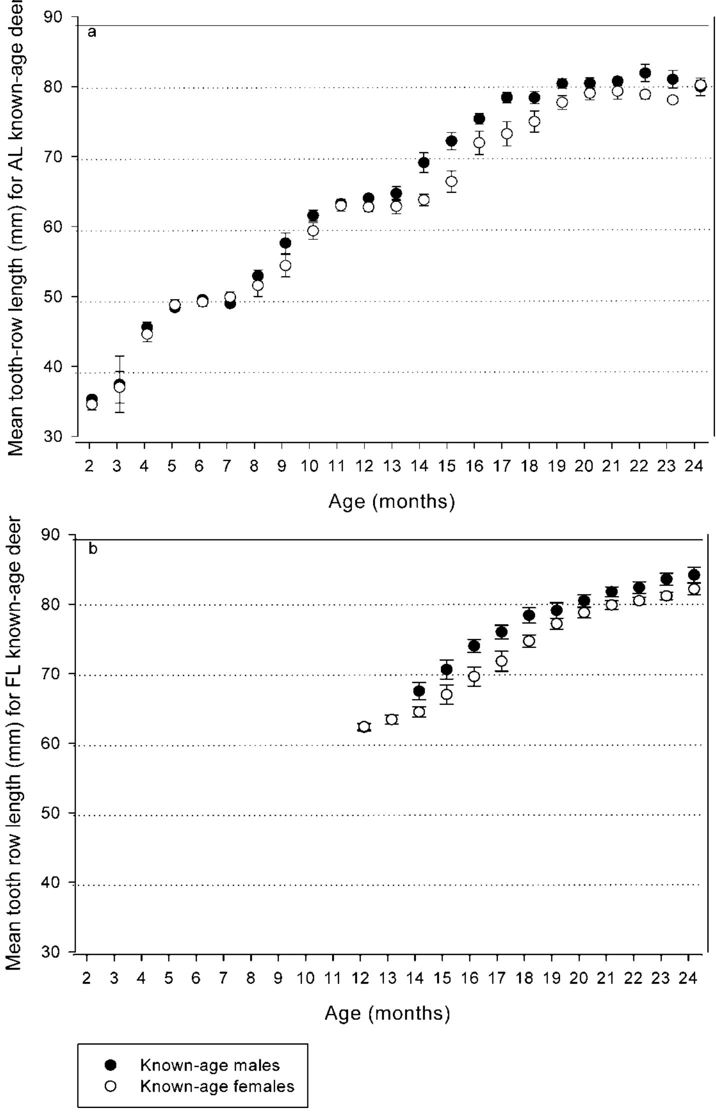

Figure 2. Gender-influenced mean length of dentition (mm) of known-age male and female white-tailed deer at the a) Auburn University Deer Research Facility, Auburn, Ala., USA (model data collection 1989–1991), and b) Deer Research and Education Facility at Tyndall AFB, Fla., USA (test data collection 1993–1997).

days. One (5-months-old) of 2 females (5-months-old and 18-months-old) fell within 28 days.

Discussion

Given the inherit variability in tooth eruption and size within mammalian species, individual organisms would be expected to vary because of genetics and environmental conditions. By measuring mandibular tooth row length (which includes the erupting molars in the measurement even if only half the tooth has erupted above the gumline), we attempted to overcome natural variation associated with the timing of tooth loss and eruption of incisors, premolars, and molars.

Shea et al. (2002) used the eruption of the third molar in a model to age yearling white-tailed deer. The mean age of eruption of the third molar by male deer was 19.06 months ($n = 17$; SE = 0.35) and by female deer was 21.55 months ($n = 11$; SE = 1.69) for the Florida white-tailed deer. Mean age of eruption of the third molar for the Florida white-tailed deer on the 9% protein diet was 19.00 months ($n = 13$; SE = 0.28) and deer on the 25% protein diet was 20.93 months ($n = 15$; SE = 1.29). The eruption of the third molar ($r^2 = 0.77$ for males and $r^2 = 0.79$ for females) was not as strong a predictor of age as was the mandibular tooth row length measurement ($r^2 = 0.93$ for males and $r^2 = 0.92$ for females). When we tested both equations, we found that the mandibular tooth row length model provided a better fit than the eruption value of the third molar, which predicted <25% of test jaws to within 7 days.

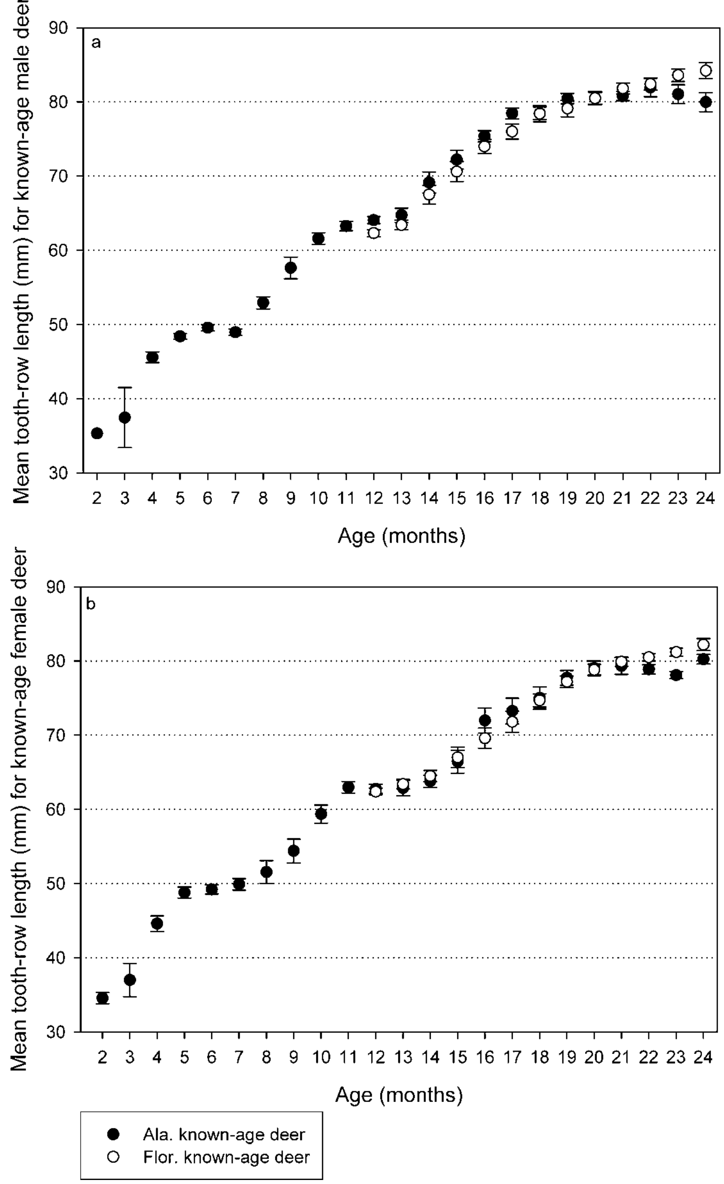

Figure 3. Mean length of dentition (mm) of the lower right jaw from captive known-age a) male deer and b) female deer from Auburn University Deer Research Facility, Auburn, Ala., USA (model data collection 1989–1991) and the Deer Research and Education Facility at Tyndall AFB, Fla., USA (test data collection 1993–1997).

Assessing factors that may influence the applicability of this method is critical to a review of any new technique. We feel that nutrition, gender, and subspecies of white-tailed deer may affect model use since mandibular tooth row length is a function of jaw size. Verme and Ullrey (1984) stated that 14–22% protein (dry-matter basis) was required for fawn development following weaning. Ullrey et al. (1967) observed that male fawns had higher protein requirement than females. We observed a dietary difference in the mandibular tooth row length in the Florida male white-tailed deer between 16 and 24 months of age subjected to the 9% vs. 25% protein extremes in diet. The dietary difference in mandibular tooth row length could be accounted for by the rate at which male deer are putting on body mass and are, therefore, under greater nutritional demands at that age.

Male white-tailed deer are slightly taller and weigh more than females at the same age (Sauer 1984). Van Deelen et al. (2000) commented that due to differences in gender size, male teeth would be larger than female teeth. Van Deelen et al. (2000) documented differences in gender in tooth morphology and wear of molariform teeth in white-tailed deer >1.5 years old. Gender differences in mandibular tooth row length was apparent for both the Alabama and Florida white-tailed deer and could be contributed to sexual dimorphism.

We acknowledge that our study methodology may have influenced our data. Little is known about the effects of monthly sedation and reversal on body growth and dentition (Day et al. 1980). Yearling deer at the Auburn University Deer Research Facility that were not sedated were larger than the study deer (i.e., yearling body weights 59.4–64.4 kg) at 18 months of age (M. K. Causey, Auburn University [retired], Auburn, Ala., USA, personal communication). Mean weight of captive yearling Alabama white-tailed deer used to create the model ranged from 43.1 kg for females to 51.2 kg for yearling males (Clawson 1992). Average weight for free-ranging yearling white-tailed deer males from the lower coastal plain, black belt prairies, upper coastal plain, and limestone valleys–uplands of Alabama were 43.9, 45.8, 48.1, and 52.6 kg, respectively (Cook and Gray 2003). Weight of free-ranging white-tailed deer that are 1.5 years old from northwest Florida (deer used to validate the model) ranged 45.4–48.9 kg for males. Average weight for 1.5-year-old females from northwest Florida ranged 36.7–40.3 kg (A. H. Kane, Florida Fish and Wildlife Conservation Commission, Tallahassee, Fla., USA, personal communication).

The average weight of captive deer used for the model fell within the average weight of deer throughout Alabama (Gray et al. 2002) but were heavier than northwest Florida free-ranging deer. Even with the difference in mean body weight between deer in Alabama and Florida, >50% of the test males and 60% of the test females were correctly aged within 7 days between 16 and 24 months of age. This aging technique achieved the highest accuracy by correctly predicting age within 7 days for males and females tested at 18 months and at 19 and 21 months, respectively. Thus, we believe this technique would perform well in other southeastern states with deer of comparable size.

The equations we used substantially overestimated age of Severinghaus's deer because the mandibular tooth row length is longer for deer from New York. Therefore, in regions where white-tailed deer body mass differs from those we used, biologists should consider creating their own regression equations using known-age deer from their locale.

Management Implications

Aging Technique

Age is an integral component of many techniques that have been developed to analyze harvest data (Larson and Taber 1980). Biologists can use harvest data to determine herd age distribution, calculate fawn:doe ratio, create life tables, and analyze condition indices and use in models to predict future population structure or recruitment. We believe the equation aging method we developed is easy to perform and would eliminate individual bias when aging deer between 16 and 24 months of age. The regression equations we describe in this paper would be applicable for use by deer biologists in the southeastern United States, where the body weights fall within the model and test deer range. This method should not be used by biologists in areas where the body weights fall outside the range because mandibular tooth row length is dependent upon size.

Evaluate Condition Indices

Currently, in southeastern United States, white-tailed yearlings are being lumped into the same age class even though ages may differ by 6 months or more. This affects management when comparing or evaluating condition indices of herds (Gray et al. 2002). For example, in northwest Florida, breeding season varies by 2 months. Yearling bucks from this area exhibit differences in both body weight and antler development although population levels and habitat are similar (Shea et al. 1992). In regions where this technique is applicable, it would allow biologists to better evaluate and compare condition indices of yearling deer.

Evaluate Breeding Chronology

Several southern states have wide variability in breeding chronology. Breeding dates for white-tailed deer in Florida extend over 6 months from late summer in southern regions to late winter in northwest regions. Differences in breeding dates are the reason for the establishment of varying hunting season dates in Deer Management Zones (DMZ) in Florida and some other southern states. Zone delineation often is based on limited fetal measurement or blastocyst data from a relatively small number and distribution of deer collections. This equation provides a more comprehensive tool to evaluate differences in conception and parturition dates in these areas and could be used to more accurately delineate DMZ boundaries.

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