Aging Fetal White-Tailed Deer

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Abstract: Reproductive performance was monitored in a captive herd of white-tailed deer *(Odocoileus virginianus virginianus)* at the Dennis Wildlife Center in Bonneau, South Carolina, from 1980–84. Sixty-four known-age fetuses, including 25 sets of twins, were obtained from 39 does that were 1.5–3.5 years old when bred. Fetuses were obtained at weekly intervals from 5–27 weeks. Weights and a series of standard measurements were recorded from all fetuses. The relationship between each measured parameter and fetal age in days through gestation was linear (r^2 = 0.84–0.99, $P < 0.001$). A key to fetal development was constructed using weights, measurements, and morphological characteristics.

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Initial studies of fetal development in white-tailed deer involved the northern subspecies *(O. v. borealis).* Cheatum and Morton (1946) produced a growth curve using forehead-rump measurements of 20 known-age fetuses from 12 captive New York does. A key to fetal development constructed by Armstrong (1950) was based on external meristic and descriptive data of 76 fetuses obtained from wild does throughout New York State. Those fetuses were aged by Armstrong according to Cheatum and Morton's (1946) growth curve.

A fetal scale for white-tailed deer was developed in the late 1950s by the West Virginia Conservation Commission and provided biologists a simple but practical approach to aging fetuses. However, their scale contained a word of caution: "Data for scale taken from Cheatum and Morton (1946) and Armstrong (1950) are valid only for white-tailed deer in Northeastern U.S."

More recently, Short (1970) examined morphological development and aging in 21 known-age Michigan white-tailed deer fetuses obtained from captive does.

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Prediction equations using standard body measurements and oven-dried eye lens weights for age determination of those Michigan whitetail fetuses were extremely accurate (r^2 = 0.90–0.99).

This study was undertaken to develop fetal aging criteria for southeastern white-tailed deer and to identify differences between data from the northeastern subspecies. Funding for this study was provided by the South Carolina Wildlife and Marine Resources Department. Many individuals, too numerous to mention, assisted in this project. The authors extend gratitude to personnel of the South Carolina Wildlife and Marine Resources Department; the Southeastern Cooperative Wildlife Disease Study and the School of Forest Resources, University of Georgia; the Savannah River Ecology Laboratory; and the Department of Forestry, Clemson University.

Methods

The deer research facility located at the Dennis Wildlife Center, Bonneau, South Carolina, covered 0.4 ha and contained a large breeding pen (39 m × 17.6 m) with 16 adjacent, smaller pens for confining individual adult does. Ten other pens within the facility were utilized to segregate various deer groups by sex and age class.

Maintenance of Research Animals

Each spring and summer from 1979–83, fawns were obtained from the wild. Approximately 15 female fawns, including those born to captive does, were reared annually. Animals were ear tagged and freeze-branded for individual identification. Young fawns were maintained in barn-type stalls and bottle-fed according to techniques described by Kirkpatrick and Scanlon (1984:687–696). At 2 weeks of age a pelleted ration (Calf Startena, Ralston Purina) containing 16% protein was made available to all fawns. French et al. (1956) reported that fawns require 13–16% crude protein for optimum growth. The dietary crude protein maintenance requirements for white-tailed deer was reported to be 6–7% (Dietz 1965, Murphy and Coates 1966, Wallmo et al. 1977). Verme and Ullrey (1974), however, recommended feeding 13–20% crude protein believing that 16–17% more closely meets the maximum requirements of most deer, including lactating does. The animals in this study were fed a diet of Omolene 300 (Ralston Purina) containing 16% crude protein and essential vitamins and nutrients.

Simulating the natural seasonal undulations of available nutrients proved impractical and unnecessary. A study of nutritive value of selected deer foods in South Carolina by Thorsland (1966) revealed that, on the average, those plant species studied contained the 17% protein required by deer.

Surveillance of Breeding

Beginning 15 August and proceeding through March each year, bucks were paired with does once or twice daily for 5–30 minutes. Otherwise, bucks and does remained segregated. Detailed records of breeding behavior were maintained. Bucks used for breeding ranged from 1.5 to 4.5 years old, whereas does were in the 1.5–3.5 age classes.

Data Collection and Analysis

Following each breeding season selected does were euthanized with T-61 (Euthanasia solution, Taylor Pharmacal Co., Decatur, Il 62525) to provide fetuses of known age. At necropsy, ovaries were collected, labeled, and fixed in AFA solution, and the gravid uterus was removed intact for examination. Fetuses were excised, and sex (when distinguishable) and litter size were determined. Excess amniotic fluid and extraneous membranes were removed and fetuses were weighed to the nearest 0.1 gm. Fetal measurements included forehead-rump length, foreleg and hindleg length, shoulder height, ear length, head height and breadth, contour length, and circumferences of neck, chest and abdomen (Armstrong 1950, Short 1970). Linear measurements were determined with a steel ruler or vernier caliper. Contour length and circumferences were determined with a length of dental floss which was transferred to a steel ruler and measured.

All measurements and weights used for statistical analyses and the key to fetal development were recorded from fresh specimens. Fetuses were labeled and preserved in 10% formalin for subsequent evaluation of morphological development. After specimens had been preserved in formalin for 8–48 months, they were remeasured to determine the degree of shrinkage.

The relationships between fetal weights and age and fetal measurements and age were described using regression analysis (Neter and Wasserman 1974). An analysis of covariance was used to test for differences between sexes and litter size.

Results and Discussion

Prediction Equations for Fetal Age

Linear relationships (r^2 = 0.84–0.99) between each measured parameter and fetal age in days (FAD) were significant ($P < 0.001$). Forehead-rump length (FRL) had the best predictive value ($r^2 = 0.994$) of measurements used during this study.

Differences ($P < 0.001$) were found between prediction equations (FAD vs. FRL) for sex and litter size. Even though equation coefficients were similar, the small variances with forehead-rump length obtained throughout this study resulted in differences ($P < 0.001$) between sexes and age (male: FAD = 37.42 + 0.31 FRL; female: FAD = 38.12 + 0.31 FRL) and between litter size and age (single: FAD = 35.28 + 0.32 FRL; twins: FAD = 37.68 + 0.32 FRL). For management purposes, it was decided not to use separate prediction equations for sex and litter size. The overall prediction equation for singles or twins of either sex is: FAD = 36.82 + 0.32 FRL ($N = 64$, $P < 0.001$).

Forehead-rump measurements were plotted against fetal age in days, and development was linear from the late-embryo stage (35 days) through the entire fetal period (Fig. 1). Growth curves of Cheatum and Morton (1946), Armstrong (1950),

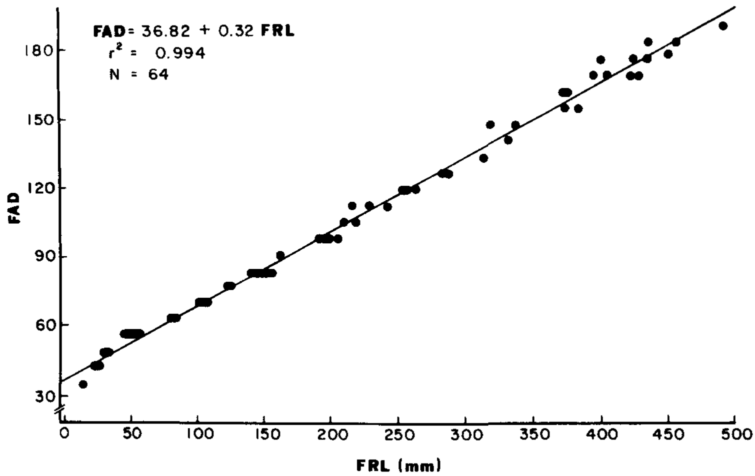

Figure 1. Relationship between fetal age in days (FAD) and forehead-rump length (FRL) for known-age fetuses from captive white-tailed deer in South Carolina ($P < 0.001$).

and Hudson and Browman (1959) were slightly sigmoid. The curvilinear portion (embryonic period <37 days) of those graphs probably resulted from the inclusion of measurements from specimens taken near the time of implantation (≃28 days), a period characterized by slow development.

When known-age fetuses from this study were aged by the techniques of Cheatum and Morton (1946) and Short (1970), estimated ages generally were within 7 days of actual age. Also, accuracy of the prediction equation from this study was tested by estimating ages of Cheatum and Morton's (1946) known-age fetuses. Extremes in deviation between estimated and actual ages were −2.4 and +4.9 days.

Age Determination by Fetal Key

Armstrong's (1950) fetal key was used as a guideline for construction of a key to age fetuses from southeastern whitetails (Table 1). Our key is divided into weekly categories, whereas Armstrong presented information at irregular intervals ranging from 5 to 30 days. Therefore, we were able to more closely define the time of emergence of some characteristics. Initial appearance of certain morphological characteristics is inconsistent in the 2 keys; Armstrong's key would assign older ages to our early stage fetuses and younger ages to those in the second trimester. Ages occasionally differed as much as 10–14 days.

In comparing our data with those from other studies, we were aware of the disparity of handling procedures, collection times, and sample sizes. Of considerable interest was the possible effect of formalin on fetal measurements, since some studies (e.g., Armstrong 1950) dealt with age determination of preserved speci-

Table 1. A key to fetal development of southeastern white-tailed deer (revised from Armstrong 1950).

Fetal Age (days)	FRL[a] (mm) Range	Weight (gm) Range	Most Recognizable Characteristics
35–41	<14	<0.3	1) Head flexed ventrally, body translucent 2) Limb buds formed, distal end flattened 3) Embryo C-shaped, wrapped around liver
42–48	15–24	0.4–1.1	1) Limbs slightly segmented, dewclaws appear 2) Digits form 3) Tail approximately same length as limb buds
49–55	24–32	1.2–2.8	1) Embryo shaped like fish hook, mammary glands present 2) Digits differentiated 3) Limbs longer than tail
56–62	33–56	2.9–8.0	1) Metatarsal glands present, not distinct 2) Examination by transmitted light shows presence of hemopoietic tissue in long bones of limbs 3) Nose adult-like, with vibrissae follicles present, slightly pigmented
63–69	57–83	8.1–18.5	1) Head not flexed ventrally 2) Fetus adult-shaped, able to sex 3) External ears folded toward eyes
70–76	84–105	18.6–40.3	1) Sagittal suture more prominent than coronal suture 2) Ears formed and folded downward 3) Gray pigment present on top of nose
77–83	106–125	40.4–61.0	1) Ears lying back against head 2) Vibrissae broken through skin over eye in position of eyebrow, under eye, on muzzle, between rami of lower jaw, and on cheeks 3) Unpigmented (white) spots on anterior and dorsal surface of nose
84–90	126–152	61.1–105.0	1) Light pigmentation on bulbous part of hooves 2) Genitalia well formed 3) Gelatinous swellings on side of head behind eyes approx. 45°, future site of antler buds
91–97	153–163	105.1–134.0	1) Nares open partially 2) Light pigmentation on dewclaws, dark pigment on bulbous part of hooves 3) Slight pigmentation on top fold of eyelids
98–104	164–206	134.1–258.0	1) Slight pigmentation on bottom fold of eyelids 2) Nares open 3) Tarsal glands beginning to appear
105–111	207–220	258.1–287.0	1) Forehead near normal 2) Tarsal glands visible 3) Translucent appearance diminishes
112–118	221–244	287.1–426.1	1) Spot formation faintly visible dorsally 2) Crown of head somewhat darker than rest of body
119–125	245–265	426.2–526.3	1) Light pigment appears in antler bud region 2) Ventral surface of trunk lighter than dorsal surface 3) Pigment patches around eyes, crown more darkly pigmented than trunk

(Table 1. continued)

Fetal Age (days)	FRL[a] (mm) Range	Weight (gm) Range	Most Recognizable Characteristics
126–132	266–288	526.4–750.5	1) Line of hair on underside of neck appears 2) Body hair begins to appear, eyelashes appear 3) Facial hair appears dorsally and parallel to eyebrows
133–139	289–315	750.6–883.4	1) Hair appears on tail and trunk 2) Spot formation visible 3) Facial hair sparse
140–146	316–333	883.5–1132.0	1) Hair appears around metatarsal glands 2) Trunk hair sparse, trunk slightly gray 3) Facial hair moderate
147–153	320–338	935.1–981.9	1) Row of stiff hair appears around edge of tarsal glands 2) Hair on crown golden brown 3) Stiff bristles sparse around top of hooves
154–160	375–385	1497.3–1521.7	1) Trunk moderately gray, hair moderate 2) Hair in tarsal glands light colored, hair around metatarsal glands light, area around glands lightly pigmented 3) Stiff bristles moderate around top of hooves
161–167	373–375	1323.0–1679.0	1) Hair around metatarsal glands moderate and darkly pigmented 2) Brown hair appears in spots along middle of back 3) Hair in tarsal glands dark colored
168–174	376–430	1679.1–2204.0	1) Hair covering complete 2) Fawn colored 3) Teeth partially covered with membrane
175–181	402–436	1728.0–2083.8	1) Metatarsal glands hair covering nearly complete 2) Tarsal glands hair covering nearly complete
182–188	437–457	2083.9–2699.9	1) Metatarsal glands with complete hair covering
189+	458–492	2700.0–3158.2	1) Incisors and canine teeth completely bare of membrane 2) Tarsal glands with complete hair covering 3) Appears as term

[a]FRL = Forehead – Rump Length

mens but used measurements of fresh specimens. We measured 42 fetuses, including singles and twins of various ages, that had been preserved in 10% formalin for 8–48 months. Average shrinkage was 6% with a range of zero to 11.4%. We detected no consistent pattern of shrinkage in relation to fetal age, time preserved, or litter size.

Conclusions and Management Implications

Forehead-rump length has been used widely to age fetuses in field studies because it is an objective measurement and is easily obtained. Most importantly, the forehead-rump length (crown-rump or neck-rump length for embryos) is the only measurement that can be applied to small fetuses, the size frequently encountered during late-fall hunting seasons.

Although other fetal aging techniques have been relatively accurate in estimating ages of southeastern whitetail fetuses, our prediction equation (using forehead-rump length) and key to fetal development provide valuable additional information that can be used to develop a revised fetal aging scale. Such a scale can enable wildlife biologists to detect changes in breeding and fawning seasons possibly resulting from the long hunting seasons and liberal bag limits, characteristic of the Southeast.

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