White-tailed Deer Breeding Chronology Project
Preliminary Summary Report
Florida Fish and Wildlife Conservation Commission
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INTRODUCTION

Information on breeding chronology and estimation of reproductive potential are crucial to understanding the dynamics of wildlife populations. With game species such as the white-tailed deer (*Odocoileus virginianus*), understanding variation in dates and duration of breeding activity is critical to scheduling hunting seasons with respect to reproductive phenology.

In northern deer ranges, the duration of breeding and parturition is short and well defined with little geographic variation. In southeastern states, however, significant temporal and spatial variations in breeding season have been demonstrated. Florida is particularly unique among southeastern states because asynchrony in breeding dates can be as much as 6 months (Richter and Labisky 1985). In addition, considerable gaps in the reproductive data exist, particularly in northwest Florida where harvest can occur prior to the peak of breeding, and hunter-harvested deer therefore cannot be used reliably to determine mean conception and productivity. This presents a challenge when developing management regulations such as the timing and length of hunting seasons. In addition, the current boundary of the hunting zone in Florida Fish and Wildlife Conservation Commission's (FWC) Northwest Region has been under considerable debate recently, and the need for updated, comprehensive data on white-tailed deer breeding chronology is pressing.

The primary purpose of this project was to obtain breeding chronology data on female white-tailed deer in northwest Florida from Madison and Taylor counties west to Escambia County. In addition, 2 sites in the Southwest Region were sampled due to a critical need for data in this area. The results of the project provide white-tailed deer breeding dates that can be used to strengthen the credibility of decision-making and broaden public support for management decisions regarding hunting zone boundaries and season dates. In addition, we examined age-specific prevalence of pregnancy, productivity, fecundity, fetal sex ratios and condition indices of deer across a variety of habitats, soil types and ecoregions. These estimates of reproductive potential can be used in predicting population trends, assessing herd health and recommending harvest rates. Furthermore, the results of this project will assist FWC managers in implementing key components of the recently approved 10-year White-tailed Deer Management Plan.

This summary report includes descriptive overall results and preliminary analyses. A comprehensive report and further analysis will be presented in the Final Report, which will be available online at www.myfwc.com/deer

STUDY AREA

Collection sites were distributed in the Northwest Region from Jefferson to Escambia county; Madison and Taylor counties in the North Central Region; and one study site each in Lake and Pasco counties in the Southwest Region. Collection sites included farms that harvested deer under depredating deer permits, private hunt clubs, plantations, timber company lands and three wildlife management areas (WMAs). To increase spatial coverage of samples, collection efforts were distributed as widely as possible across the region (Figure 1).

METHODS

Deer were collected during March – July 2009, by FWC personnel and volunteers by shooting with a high-powered rifle (neck-shots were preferred/encouraged) with the aid of a spotlight after dark or from deer stands during daylight hours. Evening collection crews consisted of a minimum of 3 individuals; a driver/guide that was familiar with the area, a spotter and an experienced shooter. Only adult does were targeted, however, data were collected from all harvested deer, regardless of age, sex or reproductive status.

Deer Collection and Necropsy Procedures

We harvested a total of 199 deer; 181 females and 18 males. Our goal was to collect 5-10 adult does per site; a sample size of 5 is considered the minimum for assessing herd health based on Southeastern Cooperative of Wildlife Diseases Study (SCWDS) guidelines. We achieved this goal on a majority of our sites. Age distribution of the harvested females was 37 (20%) fawns, 27 (15%) yearlings and 117 (65%) adults. Age distribution of harvested males was 10 (56%) fawns, 2 (11%) yearlings and 6 (33%) adults.

Immediately after the deer was harvested, we collected cardiac blood samples using a 16-gauge needle and syringe. We recorded the harvest location (geographic coordinates) and attached a unique identifying tag to each deer. Complete necropsies were conducted either the night of the collection or the following morning. We recorded total body mass and eviscerated carcass mass and estimated age based on tooth wear and eruption (Severinghaus 1949). We followed the standard aging procedure used at WMA check-stations, i.e. 0.5 year olds, 1.5 year olds, 2.5 year olds, etc. We combined age-classes into: 0.5-year-olds (fawns), 1.5-year-olds (yearlings), 2.5+ year-olds (adults) for some analyses where appropriate.

We used 4 indices to evaluate physical condition of the deer including tail, heart, kidney and pericardial fat (SCWDS herd health guidelines, Appendix A). In addition, we removed and weighed each kidney with the surrounding fat and the connective tissue capsule (tunica fibrosa). We then removed the fat and connective tissue capsule and reweighed the kidneys. Kidney fat index (KFI) was calculated as the ratio (%) of kidney fat (KF) to kidney mass (KM) (Riney 1955). These indices were used to determine an overall body condition score of poor, fair, good, or excellent based on SCWDS guidelines. Any abnormalities, evidence of diseases, injuries or parasites were noted.

We collected the entire uterus with fetuses from pregnant does and recorded the number and sex of fetuses. Age-specific productivity was expressed as the number of fetuses per all harvested does. Fecundity was expressed as number of fetuses per pregnant doe. We aged the fetuses based on crown-rump length (measured to the nearest mm) and derived the conception dates by backdating the estimated fetal age(s) from the harvest date (Hamilton et al. 1985). For females carrying twins or triplets, conception date was based on the mean fetal ages. We estimated mean conception date for a specific area (i.e., hunt club, WMA) based on all pregnant does collected in that area. In Escambia, Santa Rosa, and Okaloosa counties where samples came from multiple farms operating under depredation deer permits, we combined all samples for one mean estimate per county. We also combined data for one estimate in Holmes County due to small sample sizes per property.

We collected retropharyngeal lymph nodes (RLN) and obex for chronic wasting disease testing. We collected ticks and other ectoparasites in 70% isopropyl alcohol and submitted the samples for SCWDS exotic tick surveillance. If a tissue or organ abnormality was observed, samples were collected for later diagnostics. Reproductive tracts with no visible fetuses were collected and frozen for later analysis.

We used Geographic Information System (GIS) to display the data. Data summaries (means, standard deviations and univariate tests of normality) and tests for significant differences in productivity among age-classes were calculated using SAS/STAT software, version 9.2 of the SAS System for Windows, SAS Institute Inc., Cary, North Carolina. A significance level of 0.05 was used. Analysis of variance of KFI was performed using PROC TTEST after log transformation to assure normality. Qualitative condition indices were treated as ordinal (1=light, 2=moderate, 3=heavy for heart, kidney and pericardial fat and 1 = bony, 2 = lightly padded and 3 = padded for tail fat) and tested as univariate and multiple predictors of pregnancy and litter size (1 vs. >1) using PROC LOGISTIC. Age as a predictor of single vs. multiple litters was also tested with PROC LOGISTIC. Sex ratio was tested against 50:50 using PROC FREQ.

Carcass Disposal

Carcasses were donated to non-profit organizations such as the North Florida Chapter Safari Club International, Capitol Aftercare for Regenerated Ex-Offenders (CARE) and local, non-profit organizations including churches and other organizations caring for people in need. If we were unable to refrigerate carcasses immediately after harvest or after necropsy, they were donated to non-profit organizations housing big cats or other wildlife (e.g. Sunset Meadows, Panama City Zoo).

RESULTS

Overall condition indices ranged from fair to excellent, with over 90% of all 1.5 years and older females characterized as having good or excellent condition indices (Table 1). Mean whole body mass of females ranged from 63.1 lbs (± 12.9) for the fawns to 106.7 lbs (± 12.5) for females 3.5 years of age (Table 1). Mean KFI ranged from 20.3% for fawns to 62.5% for 4.5 year old does (Figure 2). On average, KFI was lower for fawns and the 6.5 year old age class (i.e., age was an effect for these age classes). To test whether KFI can be used to predict pregnancy (yes or no) and litter size (1 or 2+), we excluded fawns and 6.5 year olds and combined age groups into 1.5 year olds (yearlings) and 2.5+ year olds (adults). Preliminary analyzes showed that there was not a significant association between pregnancy and KFI ($P = 0.127$), however, females with two or more fetuses had significantly higher ($P = 0.022$) KFI than those pregnant with a single fawn. KFI of the single fawn that was pregnant (36.8%) was substantially greater than the mean for nonpregnant fawns (19.9%), but not significantly so ($t = 1.251$, $df = 34$, $P = 0.220$).

None of the deer examined had condition indices equaling zero for pericardial, heart or kidney fat (Appendix B). Fawns clearly had lower condition assessments, but otherwise age (yearling vs. adult) was not related to condition. Logistic regression results showed that only heart fat was a significant predictor ($P = 0.009$) of pregnancy (yes or no) while pericardial fat approached statistical significance (0.075). Pericardial ($P= 0.005$) and kidney fat ($P = 0.032$) were good predictors of litter size (1 vs. 2+). Comparisons based on AIC indicated that no multipredictor models were superior to the univariate ones.

Based on fetal counts, overall pregnancy rate (excluding fawns) was 95.1% (Table 2). Only one of the 37 fawns was pregnant. Overall mean productivity was 1.44 fetuses/doe for yearling and 1.53 fetuses/doe for adult does. Mean fecundity was 1.44 fetuses/pregnant doe for yearling and 1.66 fetuses/pregnant adult does (2.5+ year olds). There was no significant difference in mean productivity ($P = 0.57$) or fecundity ($P = 0.79$) of 2.5 year olds and 3.5+ year old does. Of the 137 pregnant does, 56 (41%) had singletons, 78 (57%) had twins and 3 (2%) had triplets. There was a considerable difference in rates of singletons and multiple fetuses among the yearling does compared to the older age classes (Table 3), but this difference did not reach conventional significance ($P = 0.07$). Fetal sex ratio (109 females: 112 males) did not differ from 50:50 ($P = 0.84$).

Mean conception dates varied from 24 October (range 17 Oct – 4 Nov) to 17 February (8 Feb -27 Feb, Figure 3, Table 4). Individual breeding dates ranged 16 October to 15 March.

DISCUSSION AND FUTURE WORK

Knowledge of the peak breeding period or rut of white-tailed deer is of considerable interest to hunters who enjoy hunting deer during the rut, when bucks are moving and overall activity is increased. Information on breeding chronology is therefore important when developing management regulations regarding timing and length of hunting seasons. Assessing the relationship between indices of nutritional condition and productivity, region, habitat and other characteristics is essential for successful management.

Similar to previous research in Florida, we found overall prevalence of pregnancy to be high (95.1%) among yearlings and older age classes, while pregnancy in fawns was uncommon. The fecundity rate of 1.62 fetuses/pregnant adult doe (including yearlings, excluding fawns) in this study was higher than the statewide average of 1.3 (Richter and Labisky 1985, Harlow and Jones 1965), but similar to previous collections in the northwestern part of the state (e.g. Tyndall air force base 1.7 (*n*=14), Ayvalla Plantation 1.6 (*n*=14)).

Peak breeding chronology followed a general east to west trend, with mean breeding dates occurring from mid-October to mid-November in Madison and Taylor counties and during mid-February in the western-most counties. However, considerable variations from this general trend were evident, particularly in the middle counties of the Northwest Region, where peak breeding dates ranged from late December to early February within a relatively small geographic area. The late breeding reported by hunters and managers in Pasco and Lake Counties was verified by this study. This emphasizes the need for further investigation of breeding phenology in regions of the state where noteworthy asynchronies in breeding dates are suspected.

Our goal was to obtain a wide geographic distribution of samples and therefore sample sizes per area were often small. Small sample sizes may have contributed to some of the apparent fluctuations in mean breeding dates among close areas. It is also important to note that the fetal scale provides as an estimate of the fetus age based on the fetal length. Numerous factors such as size and age of the doe, physical condition of the doe, litter size and habitat conditions can influence the length of the fetus and therefore the estimated age. To analyze the breeding chronology data further, we will use geostatistical treatment of the spatial data (e.g., Schabenberger and Pierce, 2002). This will allow spatial interpolation in GIS with kriging methods to estimate values at unsampled locations based on estimates made at sampled sites. The rationale behind spatial interpolation is that data points closer together in space are more similar in attributes than those further apart, a process called positive spatial autocorrelation. With spatial interpolation we will be able to create a continuous surface map of breeding dates and their variance for the region. Hopefully, we will also be able to highlight any major geographical discontinuities in breeding chronology. We will also investigate habitat, soil, ecoregion and landscape correlates of breeding chronology and other reproductive data. Depending on the final spatial coverage of the data, methods of analysis appropriate for lattice spatial data may also be useful to describe and differentiate major geographic subunits on the basis of breeding chronology, as may more traditional multivariate methods such as cluster analysis (Schabenberger and Pierce, 2002).

Nutritional condition of does is known to directly influence productivity (Verme 1965, 1969), and there are a number of physical indices that are used to assess nutritional condition of white-tailed deer (Kistner et al. 1980, McCown 1991, Sams et al. 1998, Osborn and Ginett 2001, Keyser et al. 2005). We found that KFI and heart, kidney and pericardial fat condition indices were generally higher in does pregnant with twins or triplets compared to those carrying singletons. It is important to note that our collections were conducted in the spring, and because condition indices fluctuate with season, it is difficult to say whether the relationships between nutritional conditions and litter size would be as evident in deer examined during the fall hunting season. Further analysis of the relationship of productivity, fecundity and twinning rates among different site conditions (e.g., landcover, soils) will be conducted. We will also examine all reproductive tracts that were frozen and examine them for corpora lutea, which will be used to provide an index of ovulation rate (Harden and Kirkpatrick 1996). Analytical methods appropriate for binomial response data will be used to investigate geographic and other potential predictors of twins vs. single fawns. Relationships between serum parameters and body condition indices will be evaluated by analysis of covariance, regression and correlation (Serrano et al. 2008). Results and maps from the additional analysis will be presented in a Final Report (posted on www.myfwc.com/deer) and subsequent publications.

ACKNOWLEDGEMENTS

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TABLES

Table 1. Age-specific total body mass (lbs) and eviscerated body mass (mean and standard deviation) and overall condition indices of female white-tailed deer, Deer Breeding Chronology Study, Florida, 2009.

Age class (years)	Mean whole body weight (±SD)	Mean eviscerated body weight (±SD)	Fair	Good	Excellent
0.5	63.1 (12.9)	44.6 (9.6)	17 (46%)	19 (51%)	1 (3%)
1.5	92.4 (11.2)	62.7 (10.1)	1 (4%)	19 (70%)	7 (26%)
2.5	99.8 (11.1)	68.3 (8.2)	4 (9%)	24 (53%)	17 (38%)
3.5	106.7 (12.5)	70.9 (9.0)	2 (5%)	25 (58%)	16 (37%)
4.5+	105.7 (13.4)	71.7 (10.8)	0	22 (79%)	6 (21%)

Table 2. Age-specific pregnancy rates (%), mean productivity (no. of fetuses/all harvested females) and mean fecundity (no. of fetuses/pregnant females), Deer Breeding Chronology Study, Florida, 2009.

Age class (years)	N	Pregnancy rate	Productivity	Fecundity
0.5	37	2.7%	0.03	1.00
1.5	27	100%	1.44	1.44
2.5	45	91.1%	1.49	1.63
3.5+	72	94.4%	1.58	1.68
Total[a]	144	95.1%	1.53	1.62

[a] Excluding fawns

Table 3. Frequency (observed number), expected frequency (assuming independence) and percentage of observed number of fetuses (single vs. twins+) of yearling and adult white-tailed deer, Deer Breeding Chronology Study, Florida, 2009.

	Age Class (years)	N	Single	Twins+
Frequency	1.5	27	15	12
Expected			*10.9*	*16.1*
Percentage			55.6%	44.4%
Frequency	2.5+	109	40	69
Expected			*44.1*	*64.9*
Percentage			36.7%	63.3%

Table 4. Mean, median and range of white-tailed deer breeding dates from 27 study areas, Deer Breeding Chronology Project, Florida, 2009

Study Area	*County*	*Mean*[a]	*Median*	*Earliest*	*Latest*	*N*[b]
Apalachicola WMA[c]	Wakulla	27 Jan	21 Jan	04 Jan	28 Feb	5
Ashley Property	Madison	19 Nov	18 Nov	07 Nov	04 Dec	5
Bloodworth Property	Madison	02 Jan	02 Jan	02 Jan	02 Jan	1
Camp Misery	Taylor	13 Nov	12 Nov	16 Oct	09 Dec	5
Concord	Gadsden	07 Dec	07 Dec	05 Dec	11 Dec	4
Diamond Bar	Lake	17 Feb	12 Feb	18 Jan	18 Apr	8
Dixie Plantation	Jefferson	28 Nov	28 Nov	24 Nov	04 Dec	3
Eglin Air Force Base	Okaloosa	13 Feb	12 Feb	28 Jan	12 Mar	11
Escambia Co. Depredation	Escambia	10 Feb	04 Feb	19 Jan	09 Mar	7
Eubanks Property	Calhoun	21 Jan	22 Jan	11 Jan	03 Feb	6
Foley Timber and Land	Taylor	24 Oct	22 Oct	17 Oct	04 Nov	4
Green Swamp West WMA	Pasco	07 Feb	06 Feb	18 Jan	05 Mar	8
Holmes Co.	Holmes	07 Feb	04 Feb	23 Jan	27 Feb	5
Liberty Co.	Liberty	03 Feb	03 Feb	27 Jan	10 Feb	2
Lily Pad Too	Jackson	04 Jan	05 Jan	26 Dec	14 Jan	3
Neal Land and Timber	Calhoun	29 Jan	01 Feb	08 Jan	06 Feb	5
Nokuse Plantation	Walton	17 Feb	17 Feb	08 Feb	27 Feb	2
Okaloosa Depredation	Okaloosa	12 Feb	10 Feb	22 Jan	14 Mar	5
Ranch	Calhoun	24 Dec	28 Dec	10 Dec	31 Dec	6
River Ridge Plantation	Leon	10 Dec	03 Dec	21 Nov	14 Jan	4
Santa Rosa Depredation	Santa Rosa	06 Feb	06 Feb	25 Jan	18 Feb	8
South 40	Bay	26 Jan	01 Feb	11 Jan	06 Feb	3
Southwood	Leon	05 Dec	04 Dec	02 Dec	11 Dec	4
St. James Island	Franklin	20 Jan	25 Jan	31 Dec	02 Feb	4
Tate's Hell WMA	Franklin	11 Jan	15 Jan	19 Dec	20 Jan	6
Tupelo Bend	Gulf	08 Feb	09 Feb	10 Jan	15 Mar	8
Windham/Smith Property	Jackson/Washington	06 Feb	02 Feb	20 Jan	20 Feb	5

[a] Mean conception dates of individual does. Conception dates were derived by backdating the estimated fetal age(s) from the harvest date. For twins or triplets, conception date was based on the mean fetal ages. Fetus age was based on crown-rump length measurement.

[b] N = number of pregnant females

[c] WMA = Wildlife Management Area

FIGURES

Figure 1. Sample collection distribution in the Northwest Region and Madison and Taylor counties, White-tailed Deer Breeding Chronology Study, 2009.

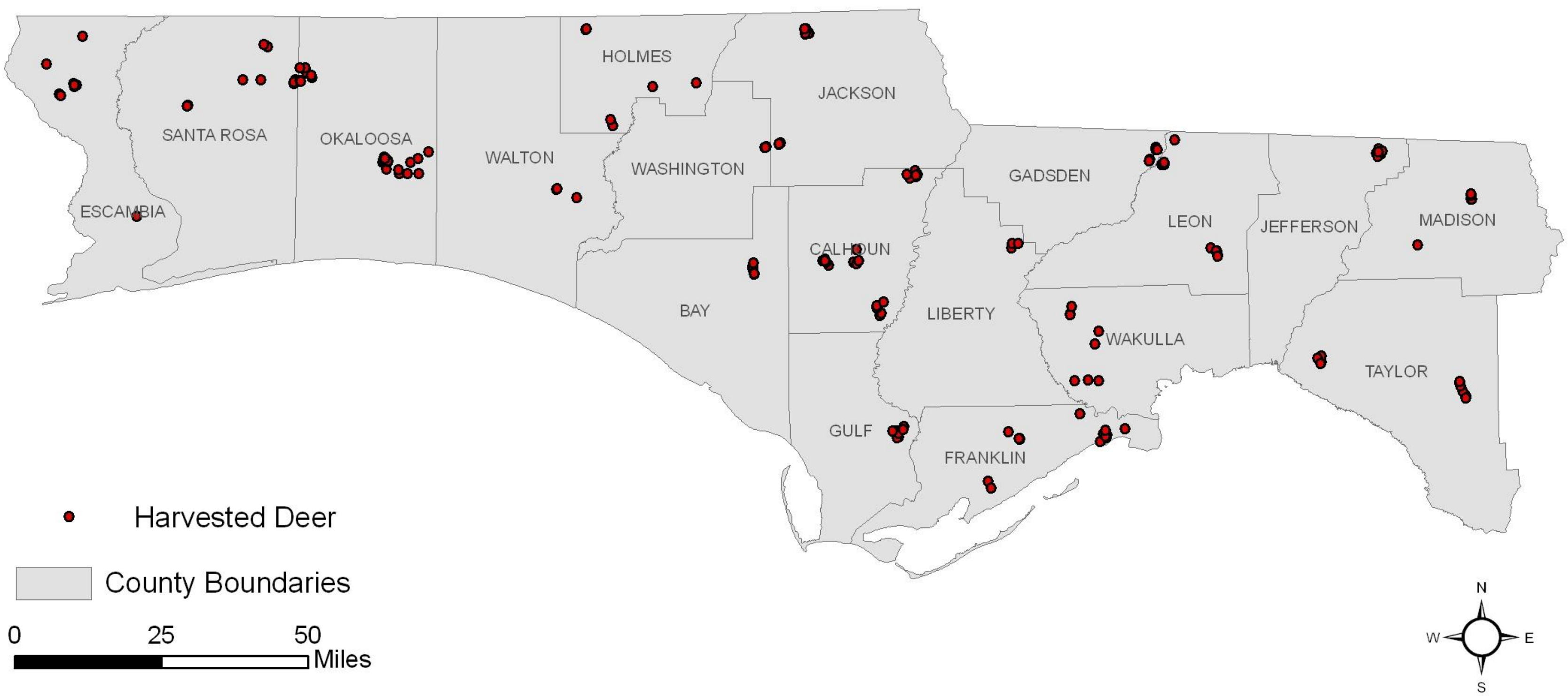


Figure 2. Female white-tailed deer kidney fat index by age-class. Boxplot widths are proportional to sample size. Whiskers show minimum and maximum, boxes show 25th percentile (lower edge), median (central line) and 75th percentile and crosses are the means.

Kidney index by age group

Mean	20.345	61.227	58.458	62.644	62.480	54.200	26.998
Min	5.066	18.813	10.204	11.017	19.055	21.942	17.936
Max	45.429	192.524	192.154	201.730	145.333	98.289	44.584
N	36	24	43	40	12	8	6

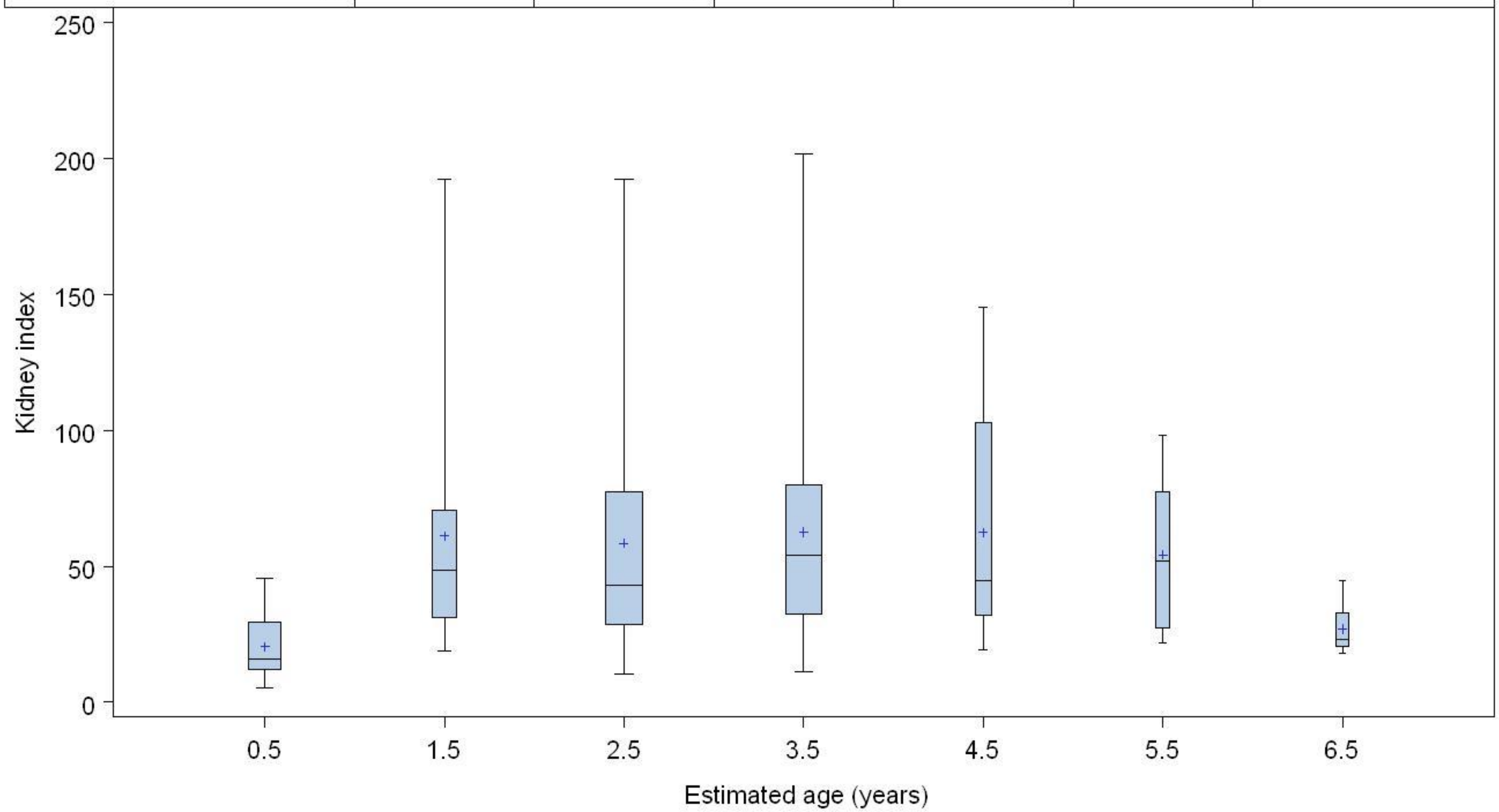
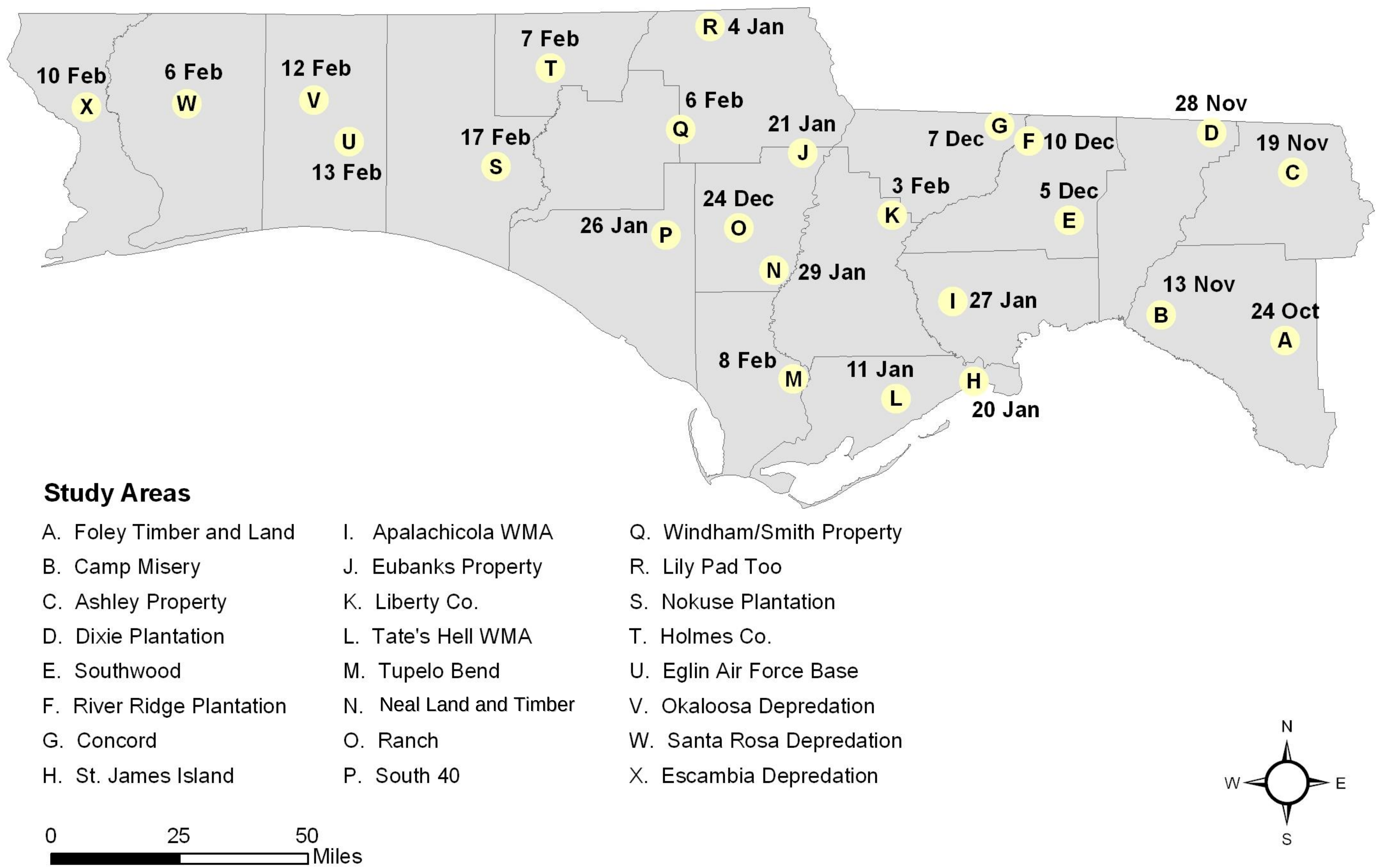


Figure 3. Mean conception dates by study area in the Northwest Region and Madison and Taylor counties, White-tailed Deer Breeding Chronology Study, 2009.



APPENDIX A

Assessment of Endogenous Fat:

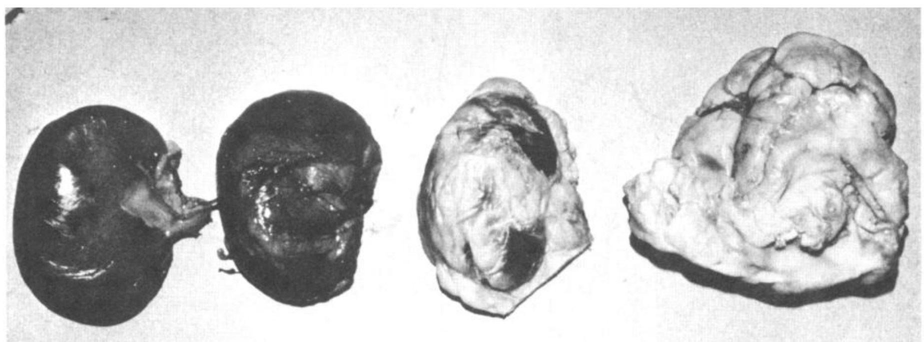
Kidney Fat Index – a visual appraisal of the amount of kidney fat was categorized in four levels.

Zero fat (0): No trace of fat anywhere on the kidney

Light fat (L): ~75% of the kidney visible; obvious fat laid in a few thin streaks or narrow layers.

Moderate fat (M): Thick layer of fat covering most of the kidney; coverage of about 50-70% of the surface.

Heavy fat (H): Kidney completely encapsulated with a thick layer of fat.



Kidney Fat Index (Kistner et al. 1980)
- 0, L, M, and H scores -

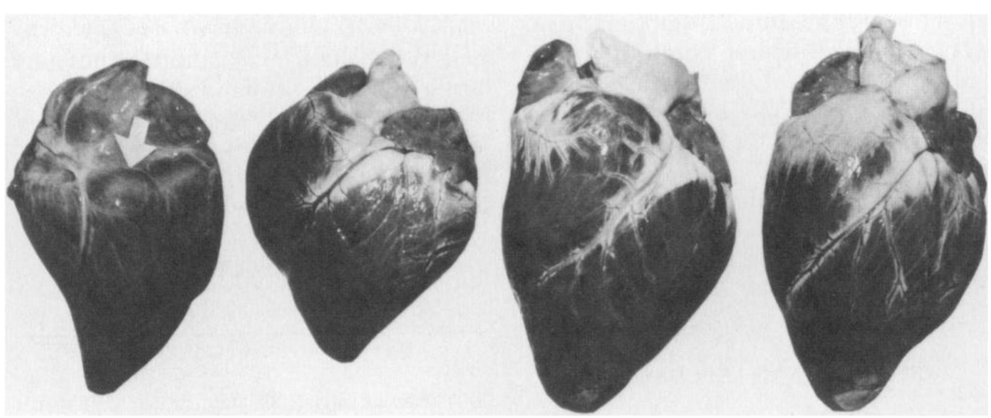
Heart Fat Index – a visual appraisal of the amount of heart fat categorized by four levels.

Zero fat (0): No trace of fat anywhere on the heart

Light fat (L): A trace of fat at the basal region with or without a trace of fat on the coronary groove.

Moderate fat (M): A moderate deposit of fat on the basal region extending slightly down the coronary groove.

Heavy Fat (H): A thick deposit of fat on the basal region extending well along the coronary groove.



Heart Fat Index (Kistner et al., 1980)
- 0, L, M, and H scores -

Pericardial Fat Index: a visual appraisal of the amount of pericardial fat categorized by four levels.

Zero fat (0): No trace of fat anywhere on the pericardium.

Light fat (L): Traces of fat at basal area, and possibly light streaks extending to apex.

Moderate fat (M): Zones of moderate amounts of fat at basal area, linear streaks of fat extending from base to apex.

Heavy fat (H): Zones of fat up to 7 mm thick at basal area, obvious linear streaks of fat extending from base to apex.

Tail Fat Index: a manual appraisal of the amount of tail fat was determined by palpating the base of the tail prior to skinning and was categorized in three levels:

Bony (B): No palpable fat between skin and coccyx

Lightly padded (LP): Small amount of fat; coccygeal vertebrae could still be felt, but sharp points padded.

Padded (P): A heavy deposit of fat present; unable to feel the coccygeal vertebrae.

Overall Physical Condition: Excluding femur marrow, all of the above endogenous deposits in addition to factors presented below are used to assess the overall physical condition of each animal. Physical condition ratings are categorized in four levels:

Poor (P): No trace of fat on the kidney, heart, pericardium, omentum, or intestines. Carcass approaching emaciation as evidenced by stringy muscle texture and varying degrees of dehydration. Tail bony and backbone very prominent before skinning. Gelatinous material may be present on the heart and omentum where fat was mobilized.

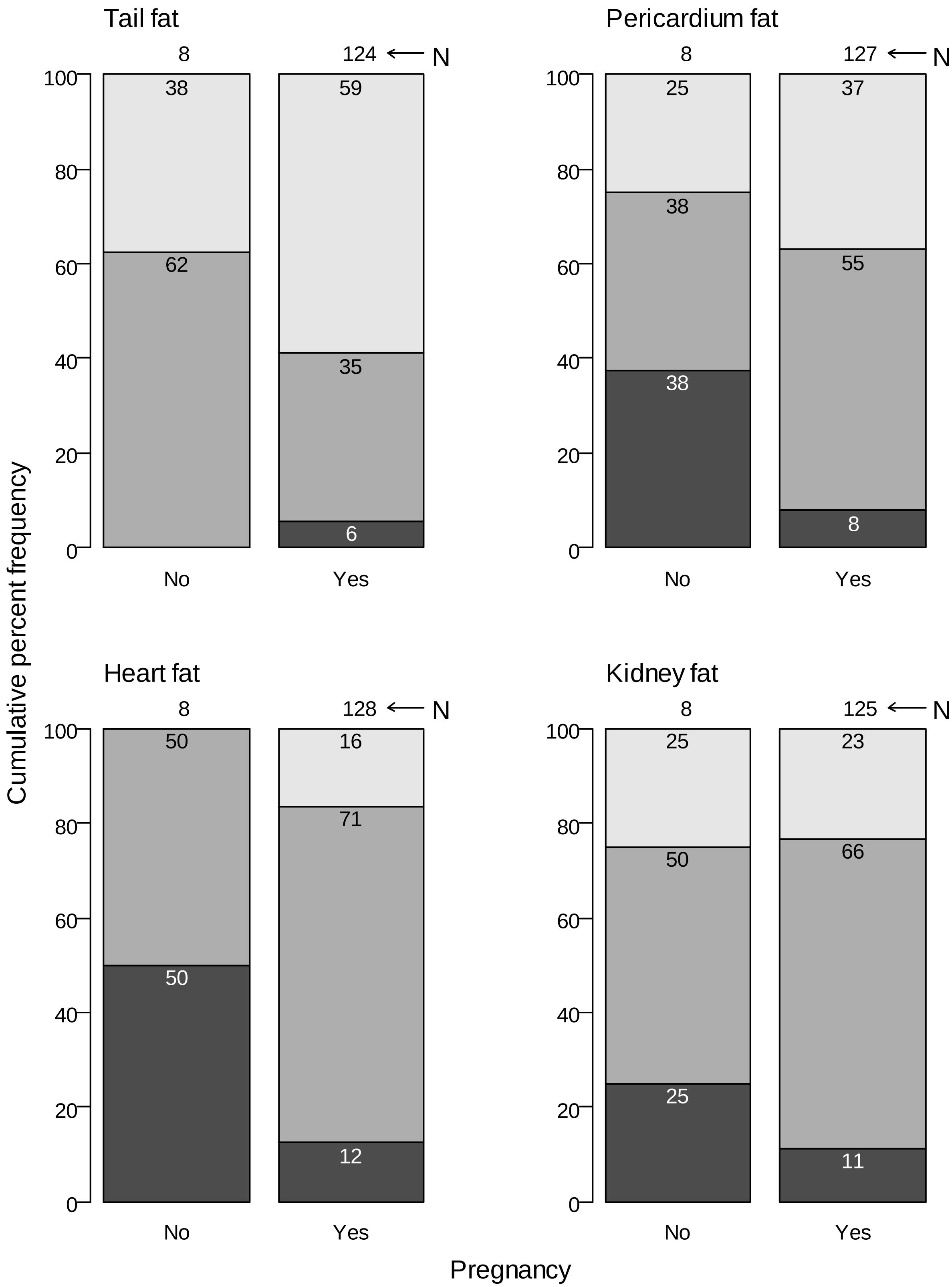
Fair (F): Zero or light fat on kidney, heart, and pericardium. Tail bony. Light deposit of fat on the omentum which may be pink in color.

Good (G): Moderate kidney fat, light to moderate heart and pericardial fat, lightly padded or padded tail, and fibrous material in omental fat. Fawns classified in good condition did not necessarily have any fat deposits provided the animals were not obviously in poor health.

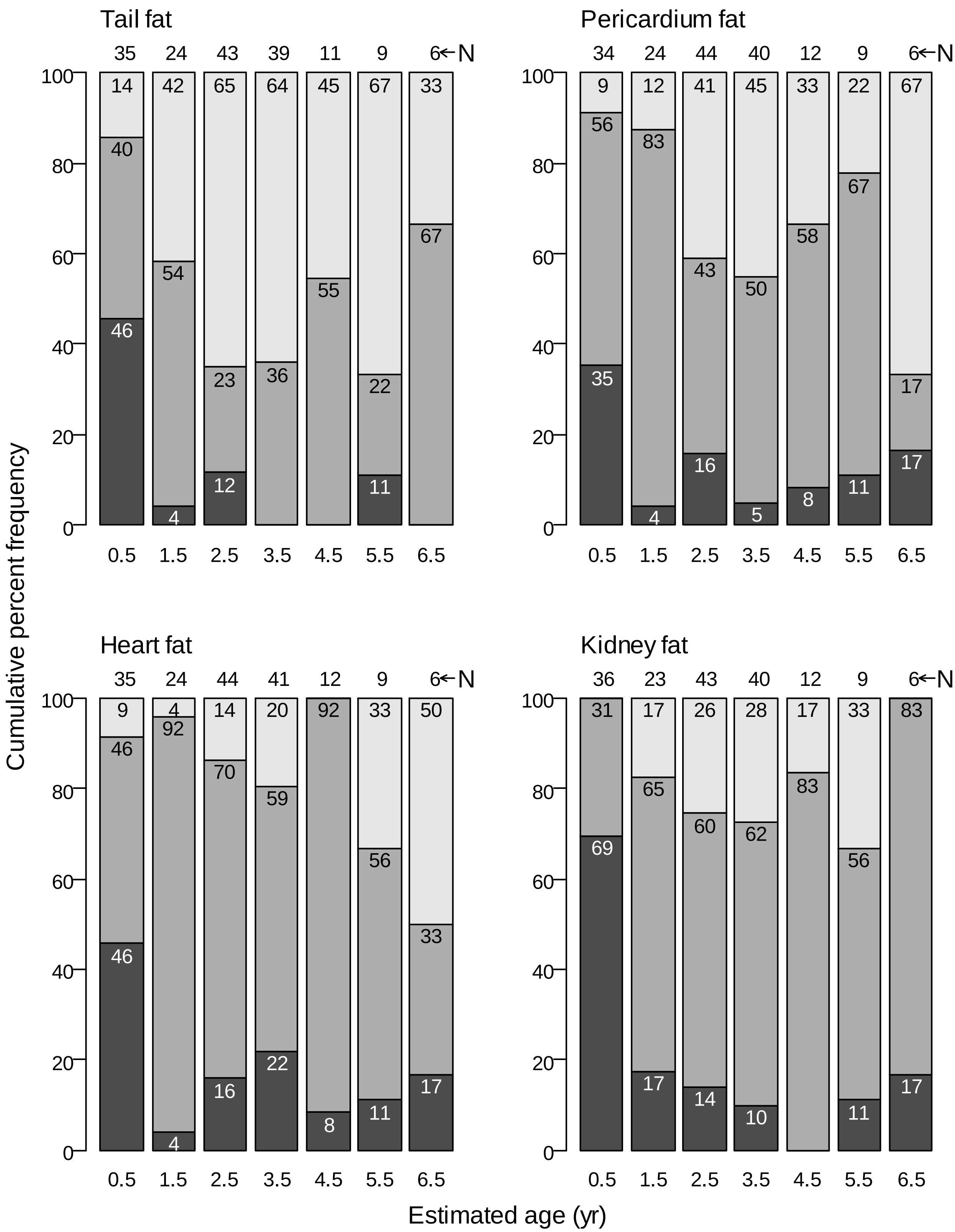
Excellent (E): Heavy kidney fat, moderate to heavy heart and pericardial fat, padded tail, heavy subcutaneous fat, back fat extending from the tail into the lumbar region, which may be as much as 12-25 mm thick at the last sacral vertebrae.

APPENDIX B

Relative representation of condition index levels for pregnant and non-pregnant females (excluding fawns). For tail fat, dark gray = bony; medium gray = lightly padded; and light gray = padded. For pericardium, heart and kidney fat, dark gray = light fat; medium gray = moderate fat; and light gray = heavy fat. Percentage of each individual condition index is given inside the columns.



Age-specific relative representation of condition index levels. For tail fat, dark gray = bony; medium gray = lightly padded; and light gray = padded. For pericardium, heart and kidney fat, dark gray = light fat; medium gray = moderate fat; and light gray = heavy fat. Percentage of each individual condition index is given inside the columns.



Relative representation of condition index levels among females with different litter sizes (excluding fawns). For tail fat, dark gray = bony; medium gray = lightly padded; and light gray = padded. For pericardium, heart and kidney fat, dark gray = light fat; medium gray = moderate fat; and light gray = heavy fat. Percentage of each individual condition index is given inside the columns.