EFFECTS OF BODY MASS, PHYSIOGRAPHIC REGION, AND ENVIRONMENTAL CUES ON REPRODUCTIVE TIMING IN DEER

By

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A Thesis
Submitted to the Faculty of
Mississippi State University
in Partial Fulfillment of the Requirements
for the Degree of Master of Science
in Wildlife and Fisheries Science
in the Department of Wildlife and Fisheries

Mississippi State, Mississippi

December 2007

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The reproductive timing and success of white-tailed deer are important to managers. I evaluated the reproductive variability of pen-raised deer and wild populations within Mississippi and investigated effects of age, body condition and moon phase on conception dates. I also examined the reproductive potential of doe fawns from 3 regions of Mississippi. Individual conception dates varied more than expected and were not related to moon phase. Age affected individual conception date, although the effect may have been confounded by estimated gestation length. Population level variation was less than reported and could not be explained by moon phase or late-winter body condition. One of 65 doe fawns bred. The critical mass for reproduction may be lower in Mississippi than previous reports for the northern U.S. Regional variation in fawn breeding based on yearling lactation rates warrants additional research.

DEDICATION

This thesis is dedicated to my wife Cassie and my parents Mark and Rebecca. Without the hard work from my parents this thesis would not have been possible. They dedicated their lives to raising me and my siblings and instilled a love of learning and the importance of education. Your teachings will never be forgotten and I thank you for that. Cassie, you are my best friend and the love of my life. Without your support, love, and constant prodding this thesis would have never been completed. Thank you for taking a chance on me and being willing to put your life on hold to follow my dream. Thank you.

ACKNOWLEDGEMENTS

I would like to thank my family for their encouragement and love. To my wife, Cassie, my parents Mark and Rebecca, and my brother and sister, Mark and Jessica, thank you for your support, thoughts, and prayers through these last several years. I would also like to thank Stephen Demarais for offering me this great opportunity to expand my horizons. I know it was a gamble and I hope you were not disappointed.

I would like to thank my committee members Bronson Strickland and Scott Willard for being willing to help me through this process. Your help and advice has helped a great deal throughout this thesis.

Funding for this project was provided by the Mississippi Department of Wildlife, Fisheries and Parks (MDWFP) through the Federal Aid in Wildlife Restoration Program (Project W-48, Study 54). A very special thank you is also needed for the entire MDWFP technical staff. The work that was invested during deer captures goes beyond any amount of thanks that I could ever express. To Chad Dacus, William McKinnley, Chris McDonald, Lann Wilf, Scott Edwards, Russ Walsh, Dave Godwin and Jim Wilcutt, I learned more from the time I spent with you than you will ever know. Thank you for your patience.

Some data for this study were provided by Bill Armstrong, Gene Fuch, and Dale Prochaska from the Texas Parks and Wildlife Department and from Harry Jacobson, Mississippi State University. Thank you for your help and ability to use the data.

I thank all of the students in the graduate student office for providing a needed distraction at times and for not being too hard on me for distracting you. I am especially grateful to Amy Castle, Stephen Webb, Brice Bond-Hanberry, and Phil Jones for being there to answer questions, moral support, and help out when I need it.

I thank the great group of student workers that assisted with the project; I could not have asked for better. Many thanks to Travis McDonald, Adam Coleman, Jonathan Ball, Ashley Tidwell-Gary, Matt Brock, Roger Tanksley, Preston Coates, Nathan Stuckey, Jayson Herndon, and Jaysen Hogue for being friends and helping out.

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CHAPTER I

INTRODUCTION

White-tailed deer (*Odocoileus virginianus*), like other seasonally polyestrous breeders, cue reproductive behaviors and estrus on photoperiod (Lincoln 1992). Use of photoperiod to time reproductive events is an adaptive trait that allows a species to time the most energy demanding periods (lactation and late gestation) during times of greatest abundance and quality (Bronson 1989). However, the reproductive timing has been shown to vary across regions and populations and is especially variable in the southeastern U.S. (Roberson and Dennett 1966, Weber 1966, Jacobson et al. 1979). Although photoperiod is the primary cue, other factors such as age of doe (Haugan 1975; Butts et al. 1978), nutrition (Verme 1965), genetics (Jacobson and Lukefahr 1998; Sumner 2004), body condition (McGinnes and Downing 1977, Cothran et al. 1987), and herd dynamics (Guynn and Hamilton 1986; Jacobson 1992) affect a doe's conception date.

Noble (1974) and Jacobson et al. (1979) documented extensive variation in population conception dates within Mississippi. Concerns over reproductive timing in Mississippi resulted in dividing the state into 2 deer management zones in 2005 so that hunting seasons could occur at equivalent points in the breeding season throughout the state. Some of the variation in mean conception date among populations has been contributed to mitochondrial DNA; however DNA cannot explain the individual variation observed within populations (Sumners 2004). Further assessment of reproductive timing can help biologists manage the state's deer population with greater effectiveness.

Knowledge of recruitment rates is vital for understanding the population status. Although the Mississippi Department of Wildlife, Fisheries and Parks (MDWFP) monitors recruitment rates of adult deer through annual herd health evaluations and data collected by Deer Management Assistance Program (DMAP) cooperators, there remain some unanswered questions. Although Noble (1974) and Jacobson et al. (1974) identified reproduction by fawns as minimal source of recruitment, data collected by the DMAP cooperators suggest otherwise. Yearling lactation rates in some regions of Mississippi approach 16% (Mississippi Department of Wildlife, Fisheries and Parks 2006); however, this deviates from the ≤4% fawn reproduction based on fetal and corpus luteum counts reported by Noble (1974) and Jacobson et al. (1979). Because harvest rates are related to recruitment rates, it is important to accurately estimate reproductive potential of doe fawns in Mississippi.

Specifically, the objectives of this study are to:

1) Quantify variation among breeding dates for deer with known breeding histories and investigate potential environmental cues.
2) Compare proportions of doe fawns from 3 physiographic regions in Mississippi that breed their first year under a high nutrition diet to wild deer from the respective regions.
3) Quantify the critical mass needed for reproduction by fawns and quantify any variation among 3 physiographic regions.

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CHAPTER II

ENVIRONMENTAL INFLUENCES ON CONCEPTION DATE VARIATION IN WHITE-TAILED DEER

ABSTRACT

Understanding the factors that influence timing of reproduction can be of value to wildlife managers. I used estimated breeding dates of confined individual deer in Texas and Mississippi and wild deer populations within Mississippi to document natural variation within individuals and populations, and to determine if body condition, age, or moon phase explained conception date variation. I used a binomial and one sample t-test to determine accuracy of moon phase as a predictor of conception date at the individual and population levels. I used mixed model ANOVAs to determine effects of age and body condition on individual- and population-level variation, respectively. Mean conception date of confined individual deer was 30 November with a median of 25 November, standard deviation of 11.9 days and a mean range of 31 days. Mean conception date for wild populations in Mississippi was 1 January with a standard deviation of 13 days and a mean range of 46 days. Annual population mean conception date had a standard deviation of 4 days and a range of 12 days. Moon phase did not predict accurately conception date for individuals or populations of deer in the southern U.S. Body condition did not influence conception date at the population level.

Individual does 2.5 years old bred earlier than does 1.5 and 3.5 years old; however, the difference was minimal and may have been influenced by the mean gestation used to determine conception date. Further assessment of the individual variation in conception date and potential environmental cues is warranted.

INTRODUCTION

Breeding season for deer is timed so the nutritionally stressful periods of gestation and lactation are at times of greatest food abundance and quality (Bronson 1989). Like other seasonal breeders, white-tailed deer (*Odocoileus virginianus*) cue reproductive events on photoperiod (Lincoln 1992). However in the southern U.S. conception dates often vary in populations that are close and in similar latitude, suggesting other controlling factors (Roberson and Dennett 1966, Weber 1966, Jacobson et al. 1979). Documented sources of variation include age of the doe (Haugan 1975, Butts et al. 1978), nutrition (Verme 1965), genetics (Jacobson and Lukefahr 1998, Sumner 2004), body condition (McGinnes and Downing 1977, Cothran et al. 1987), and herd dynamics (Guynn and Hamilton 1986, Jacobson 1992). Additionally, theories explaining variation in breeding date based on moon phase (Alsheimer 1999) have manifested in the popular literature.

Nutrition is a widely accepted source of variation in breeding date. Rocky Mountain mule deer (*Odocoileus hemionus*) and white-tailed deer fed a lesser-quality ration bred later than does fed a greater-quality ration (Verme 1965, Robinette et al. 1973). However, white-tailed does fed 30% less feed had similar breeding dates as those fed greater amounts (Verme 1969), suggesting that quantity may not be as influential as quality. McGinnes and Downing (1977) suggested that nutritional body condition was a factor in determining breeding date. Earlier conception dates in a South Carolina deer herd were related to greater kidney fat index (KFI) values (Cothran et al. 1987).

Female age has been shown to affect variation in conception date (Haugan 1975; Butts et al. 1978). Earlier fawning and conception dates were associated with increasing doe age class in deer herds in Texas and South Carolina (Butts et al. 1978; Rhodes et al. 1991), but Hansen et al. (1996) showed no difference between yearling and adult does. In Michigan later breeding dates were noted at one and 2 years of age but only at high densities (Ozoga and Verme 1982). Knox et al. (1988) found a non-significant trend of earlier estrous in yearlings versus older does. This lack of agreement on age effects necessitates further assessment to insure that data are grouped correctly for analysis.

Theories in the popular literature attempted to explain population variation in conception date. The rutting moon theory states that as light from the full moon wanes, melatonin levels increase and stimulate ovulation 7 to 21 days past the full moon (Alsheimer 1999:91). Osborn et al. (2001) found that moon phase was a poor predictor of conception date in several populations in northern and southern latitudes.

My goal was to improve our understanding of factors related to timing of reproduction in white-tailed deer. My first objective was to quantify the natural inter-annual variation of estimated conception dates of penned individuals and wild populations. Secondly, I tested if doe age, body condition, and moon phase explained variation in estimated conception dates. I hypothesized that does in better condition will have earlier conception dates than those in poorer condition and younger does may breed later than older does. I hypothesized that moon phase will not affect conception dates.

STUDY AREAS

Individuals

To evaluate variation in conception dates of individual deer, I used fawning data from the Mississippi State University Rusty Dawkins Memorial Deer Unit (hereafter MSU deer unit) and the Donnie E. Harmel White-tailed Deer Research Facility (hereafter Kerr deer unit). These research units have records on reproductive events of individual deer that can be analyzed for variation and potential sources of variation. Births were linked to dams based on behavioral observations.

Located in the city of Starkville, Mississippi, USA, the MSU deer unit is a high-fenced research area subdivided into smaller holding and rearing pens from 0.1 to 0.8 ha in size. Most deer in this facility were from various populations within Mississippi although several deer had been translocated from Virginia and Michigan. Fawning data were available from 1976 – 1996. Subsequent years of data were omitted because interbreeding between Michigan and Mississippi deer influenced conception date (Jacobson and Lukefahr 1998). I omitted deer from research projects with potentially confounding factors, such as artificially-induced late breeding (Jacobson 1983).

The Kerr deer unit is located on the Kerr Wildlife Management Area near Hunt, Texas, USA. The facility is a high-fenced 6.5 ha research unit that contains several breeding and rearing pens of varying size. The Kerr deer unit began in 1974 with approximately 40 deer from various populations within Texas and no deer have been added since 1974. Kerr deer unit data were available from 1976 – 2003. I omitted from this analysis all deer from research projects with confounding variables, such as nutritional deprivation (Harmel et al. 1989).

Populations

I assessed annual variation in estimated conception dates of 10 free-ranging populations sampled by the Mississippi Department of Wildlife, Fisheries and Parks (MDWFP) during annual herd health evaluations (C. W. Dacus, Mississippi Department of Wildlife, Fisheries and Parks, unpublished data; Table 2.1, Fig 2.1). The selected populations varied in geographic location, with only 2 populations occurring within the same county. Populations were sampled during 1991 - 2004, but each population was not sampled annually. Within the areas where deer were sampled, land use, habitat composition, and management intensity varied and should be representative of populations throughout Mississippi. The study areas were managed for recreation and wildlife, except for Camp Shelby and Monroe County East which are managed for multiple uses.

METHODS

Individuals

To quantify the normal variation in conception dates for individual deer, I selected does with a minimum of 5 years of fawning dates after 2.5 years of age. Sex ratio within breeding pens was up to one buck per 14 does, so there was a possibility of missed estrous cycles. Therefore, I excluded data points identified as a missed breeding opportunity. I plotted conception dates for each individual and excluded a data point only if it were outside of the "normal" temporal pattern for that individual. The normal pattern was determined by examining distance of observations from the individual's median conception date and distance from other observations for the individual. If an observation was isolated from the pattern and deviated greatly from the median it was eliminated as a potential missed estrus. However, I retained the observation if it was not isolated and instead was part of a loose pattern. Although this methodology was somewhat subjective it allowed me to remove artificially-induced missed estruses without reducing "natural" variation. This evaluation resulted in the removal of 22 conception date observations.

I calculated estimated conception dates for each individual by backdating from observed fawning dates using an average gestation length of 200 days (DeYoung et al. 2002). I calculated mean conception date, standard deviation, median, and range for each individual. I created a frequency distribution for individual ranges to describe within-animal variation in conception dates.

I tested effects of moon phase for individuals at 2 levels: accuracy of directional annual shifts in conception dates (i.e., shifts earlier or later than the previous year) and accuracy of the predicted conception date. I obtained moon phase data from the U.S. Naval Observatory (2006). I predicted annual conception dates for each individual based on the moon phase theory (Alsheimer 1999:91). The predicted conception date for the southern lineage deer at the MSU deer unit was 14 days after the third full moon following the autumnal equinox. The northern lineage deer at the MSU deer unit were assigned a predicted conception date 14 days after the second full moon following the autumnal equinox. For the Kerr deer unit I followed Alsheimer's (1999:161) recommendation for Texas deer and assigned predicted dates based on the full moon closest to the observed conception dates at the Kerr deer unit. The predicted conception date used for the Kerr deer unit was 14 days after the second full moon following the autumnal equinox.

Because the "rutting moon" can vary as much as 29 days across years (Alsheimer 1999:217), annual shifts in moon phase should produce changes in conception date if there is a relationship between the moon phase and conception date. To determine if the predicted and actual breeding dates changed in the same direction, I used the observation from the previous year as a baseline value to determine the directional shift for observed and predicted conception dates. If predicted and observed values shifted the same direction for a given year I considered them in agreement and assigned a "1," if they did not agree in direction I assigned a "0." I used a binomial test to determine if the proportion of agreements between predicted and observed differed from 0.5. If the proportion did not differ from 0.5 then directional variation in conception date was random and moon phase did not influence directional variations in conception date. If the proportion was >0.5 then directional variations in conception date were associated positively with moon phase shifts.

To test accuracy of the moon phase theory I tested deviations of observed and predicted conception dates. For each observed conception I calculated the deviation between the estimated conception date and predicted date. I calculated the median of the deviations for each individual and tested the absolute value of the median deviations of all deer using a one sample, one tailed t-test. Alsheimer (1999:91) predicts that conception dates should occur within a 2 week period 7 to 21 days past the full moon, so I tested the null hypothesis $\bar{x} \leq 8$. Because I used the absolute value of the median deviations, the null hypothesis ($\bar{x} \leq 8$) allows the mean to be within the 2 week period and still be accepted. I assumed that if the sample mean was ≤ 8 the moon phase theory would be supported by the data and if > 8 the moon phase prediction was off by at least 2 weeks and the theory was rejected. These data were not normally distributed based on a Kolmogorov-Smirnov test. However, I conducted the test without corrective measures because a t-test is robust against deviations from normality (Zar 1999:185).

To test effect of age on conception date I selected individual deer with successful conceptions at 1.5, 2.5, and 3.5 years of age. I excluded deer which bred as fawns so the 1.5 age class would be primiparous individuals. I used a mixed model ANOVA using the mixed procedure in SAS (SAS Institute 2004) to test if conception dates differed among age classes. I used individual deer as a random effect so that variations among deer would not confound the results. I also used deer unit location as a random effect to reduce potential extraneous variation. The covariance parameters for location and individual were > 0 so blocking was justified. The residuals of the model met the assumptions for normality and homogeneity of variance.

Populations

I assessed annual variation in estimated conception dates of 10 free-ranging populations sampled by MDWFP during annual herd health evaluations following guidelines presented in Demarais and Jacobson (1982) (C. W. Dacus, Mississippi Department of Wildlife, Fisheries and Parks, unpublished data). I defined a useable population as having at least 5 years of herd health evaluations with at least 10 pregnant adult (2.5 years and older; Severinghous 1949) deer in the annual sample from 1991 to 2004.

Conception dates were estimated using a fetal scale based on Hamilton et al. (1985). I calculated mean annual conception date for each population. I then calculated mean, median, standard deviation, and range of the mean annual population conception dates.

I tested the effect of the moon phase at 2 levels – accuracy of directional annual shifts in conception dates and accuracy of the predicted conception date. The predicted conception dates for the populations were 14 days after the third full moon following the autumnal equinox (Alsheimer 1999:91). I conducted tests of the moon phase theory using the same methodology outlined above for the individual variation with minor changes of the baseline values. I used the mean population conception date from the previous year as a baseline value to determine the directional shift for observed and predicted conception dates; the remainder of the test was the same as the individual analysis.

To test accuracy of the predicted date, I calculated the deviation between mean annual conception date for each population and predicted date for that year; the remainder of the test was conducted as described above for the individual deer analysis. These data were not normally distributed based on a Kolmogorov-Smirnov test. However, I conducted the test without corrective measures because a t-test is robust against deviations from normality (Zar 1999:185). I used the same null hypothesis and assumptions outlined above for the individual variation.

To test effects of body condition on conception date I used kidney fat index (Riney 1955) and eviscerated body weight of does 2.5 years and older. I used a mixed linear model using the mixed procedure in SAS (SAS Institute, 2004) to test if conception dates were related to KFI or eviscerated body weight. I used area as a random effect to reduce extraneous variation because conception dates vary among regions of Mississippi (Jacobson et al. 1979). I also used year as a random effect to further reduce potential confounding effects. The covariance parameters were > 0 for both year and area so blocking was justified. The residuals of the model met the assumptions for normality and homogeneity of variance.

RESULTS

Individuals

I evaluated conception date variation for 81 deer, 64 from the Kerr deer unit and 17 from the MSU deer unit. The mean conception date for individuals at the MSU and Kerr deer units was 30 November (SE = 1.2) with a median conception date of 25 November. The mean of the individual standard deviations was 11.9 days (SE=0.6). Individual ranges varied from 5 to 66 days with a mean of 31 days (SE = 1.6). The distribution of individual ranges was right skewed with 70% of the data between 10 and 40 days (Fig. 2.2). There were 34 deer with ranges exceeding 31 days; of these 34 deer 79% had at least one conception date that occurred at least 1 standard deviation (12 days) earlier than the deer's median conception date, and 85 % that had at least one conception date that occurred 1 standard deviation (12 days) after the deer's median conception date.

There were 65% of these deer that had at least 1 conception date at least 1 standard deviation both earlier and later than the deer's median conception date.

The moon phase did not affect individual conception dates. The proportion of observed individual conception dates with directional agreement of the moon phase shifts differed from 0.5 indicating a non-random relationship ($P = 0.001$). However, the proportion (0.43) was less than 0.5, indicating that directional shifts in moon phase do not alter conception dates consistent with the moon phase theory (Alsheimer 1999: 51). The timing of the moon phase was not an accurate predictor of conception date. The mean of individual deviations from predicted dates was 12.3 days (SE = 1.2). This value exceeded 8 days ($t = 3.52$, $P = 0.004$), so the "rutting moon" theory did not accurately predict conception dates for individual deer within the 2 week interval described by Alsheimer (1999: 91).

I compared effect of age on conception date using 148 deer that conceived at 1.5, 2.5, and 3.5 years of age. Conception dates differed among the 3 age classes ($F = 4.51$, $P = 0.012$). The 2.5 year old deer conceived 6 days earlier (30 November, SE = 2.1) than the 1.5 year old deer (6 December, SE = 2.2; $P = 0.003$); however, there was no difference between the 2.5 and 3.5 year (3 December, SE = 2.3) or the 1.5 and 3.5 year old age classes ($P > 0.05$).

Populations

I examined annual variation in conception dates of 10 populations within Mississippi with 851 individual deer collected during annual herd health evaluations. The annual population means had a standard deviation of 4 days (SE = 0.5) and an average range of 12 days (SE = 1.9; Table 2.2). A typical population in my sample bred on 1 January (SE = 4.4 days) with a median conception date of 31 December (SE = 4.5), a standard deviation of 13.4 days (SE = 0.9) and a range of 46 days (SE = 3.2).

Moon phase did not affect conception dates in 10 Mississippi populations (Table 2.3). The proportion of directional shifts of predicted and actual conception dates was not different from a random proportion of 0.5 (Proportion = 0.57; $P = 0.209$). This suggests that the "rutting moon" theory as proposed by Alsheimer (1999:91) does not influence conception dates of populations in Mississippi. The 16-day mean median deviation of predicted and actual conception dates (SE = 3.7) exceeded 8 days ($t = 2.22$, $P = 0.027$), indicating moon phase was not an accurate predictor of conception dates.

The late winter body condition of deer did not affect conception dates in Mississippi. Neither mean eviscerated body weight ($P = 0.923$) nor mean KFI ($P = 0.290$) affected the mean conception dates for the 10 populations of Mississippi deer.

DISCUSSION

Variation in conception dates among Mississippi deer herds has been well documented (Noble 1974, Jacobson et al 1979, Sumners 2004). Ranges of conception dates within Mississippi populations have been reported from 55 to 103 days (Noble 1974, Jacobson et al. 1979, Jacobson 1992). Roberson and Dennett (1966) reported ranges from 13 to 95 days (mean = 64.6) for populations in Louisiana, whereas Rhodes et al. (1991) reported that 95% of deer in a South Carolina herd bred within a 60 day period. The 46-day mean range in conception dates for the 10 populations I sampled appear to be slightly below average for the southeastern U.S. This could be due to the fact that several of the previous reports used much larger political boundaries or properties (Noble 1974, Jacobson et. 1979, Rhodes et al. 1991). Sumners (2004) demonstrated that genetic variation among nearby populations could be the source of some temporal variation in conception; however his findings could not explain variation within a population.

The inter-annual variation of conception dates among individual deer is not well documented. Haugen (1959) reported the range of 2 Alabama captive deer at 11 and 57 days. The large range of conception dates of sampled deer in this study is noteworthy. My findings indicate that conception date of the average doe varied by 31 days during her reproductive life. Some of the high ranges can be explained by missed estruses that were not identified and remained within the dataset. Early embryonic mortality through 6 weeks has been reported to be 4% in white-tailed deer (Roseberry and Klimstra 1970), and subsequent recycling could explain some of the later conception dates observed. Furthermore, conception failures also could account for some of the later conceptions, although there are no estimates for rates in cervids.

Leuteal activity prior to observed estrus has been reported in white-tailed deer (Plotka et al. 1977, Harder and Moorhead 1980). Harder and Moorhead (1980) described this phenomenon as a silent estrus caused by a lower level of estrogen and progesterone than is typically seen in an overt or behavioral estrus. Verme et al. (1987) found that some captive does housed with a buck in a small pen bred earlier than does housed in a more natural situation. They suspected that the constant presence of the buck stimulated the doe to produce a full estrus in place of the silent estrus, thus allowing an earlier conception than would typically occur. Because the does in my study were housed with a buck during the early breeding season it is possible that some of the does were able to have an overt estrus during what would have typically been a silent estrus or the silent estrus occurred earlier due to increased biostimulation; which would have extended the range of breeding.

Use of a single mean gestation length of 200 days (DeYoung et al. 2002) to calculate conception date for individuals includes a potentially significant source of variation. Reported gestation lengths for white-tailed deer vary from 187 to 221 days (Haugan and Davenport 1950, Haugan 1959, Adams 1960). Verme (1965) noted the gestation length in does fed a lesser-quality feed was longer than those fed a greater-quality feed. Female bison (*Bison bison*) in good body condition that bred after the herd median conception date shortened their gestation length by ~6 days to synchronize births among the herd (Berger 1992). Verme (1989) found that litter composition (gender and number) could influence gestation length. Furthermore, primiparous individuals have longer gestation lengths than multiparous individuals (Verme 1989, Berger 1992). Because my data were collected from deer maintained under a constant nutrition the potential for increased gestation lengths due to nutritional constraints would be reduced. Because I used only adult does for the moon phase analysis, there would be no effects of primiparity increasing gestation; however, the effects of litter composition could affect the estimated conception date that was used for the analysis.

One popular theory on timing of reproduction involves the moon stimulating ovulation in does. Alsheimer (1999:54) states that as light from the full moon decreases, melatonin levels increase, and ovulation is stimulated 7 – 21 days after the second full moon following the autumnal equinox. However, Osborn et al. (2001) showed that past conception dates were a better predictor of future conception dates than moon phase for several free-ranging white-tailed deer populations. The 10 wild free-ranging deer populations I investigated support the conclusion that moon phase does not influence conception dates. My findings indicate the moon phase predicted conception date only within one month (mean deviation = 16 days +/-) of the observed conception date. Furthermore, the random pattern of directional shifts in the predicted and observed mean conception dates indicate no relationship between moon phase and conception dates.

Osborn et al. (2001) included a very small sample of individual deer (n = 2) and found mean conception dates across years to be better predictors of annual conception date than the moon phase prediction, similar to my results. My mean median deviation was well outside of the 2-week time period predicted by Alsheimer (1999:91). The weight of evidence clearly leads to the conclusion that moon phase does not influence timing of breeding in individual and populations of white-tailed deer.

My findings of effects of age on conception dates are similar to findings of Ozoga and Verme (1986) for does which successfully bred as yearlings. They found that does which successfully bred and weaned a fawn as a yearling bred on average 8 days earlier as 2.5 year olds than other 2.5 year olds which did not successfully breed and raise a fawn. By 3.5 years of age this effect of yearling breeding was not detectable and conception dates were similar to that of yearlings, in concurrence with my results.

However, my findings also contradict research conducted on the Kerr deer unit (Butts et al. 1978). Butts et al. (1978) found fawning dates occur earlier as a doe ages. However, their inclusion of deer which were unsuccessful at 1.5, 2.5, and 3.5 years of age could have affected conception dates (Ozoga and Verme 1986).

The lack of significance between the 1.5 and 3.5 and 2.5 and 3.5 year age classes suggests minimal differences among the age classes. Noble (1974) and Hansen et al. (1996) noted no difference among age classes in Mississippi and Missouri, respectively. Ozoga and Verme (1982) noted delayed conception dates in yearlings and 2.5 year olds only during periods of high density for a supplementally fed herd of deer.

Use of a single mean gestation length for all age classes could have affected the results of the age analysis. Verme (1989) found that primparous does had longer conception dates than those of multiparous does. Because all yearling does in the dataset were primparous, their gestation length could have been longer than 200 days. This longer gestation could have mimicked the effect of a later conception date by delaying the fawning date and confounded my results.

The lack of a body condition effect on conception dates differs from the findings of others (McGinnes and Downing 1977, Cothran et al. 1987, Noyes et al. 2002). There is evidence of a threshold body weight for deer to breed (Moen 1973, Robinette et al. 1973); however, body weight is not typically thought to influence reproduction in adult deer. Although conception dates have been related to body condition (McGinnes and Downing 1977; Cothran et al. 1987; Noyes et al. 2002), my KFI results indicate Mississippi populations did not respond similarly. KFI values in Mississippi peaked during December to February and decreased rapidly to April (Demarais and Jacobson 1982). Because my data were collected during the period of rapid decline, KFI values were likely highly variable. Furthermore, Cothran et al. (1987) noted that rate of fat loss also was related to heterozygosity, litter size, and time of conception, with earlier conceptions resulting in a greater rate of fat loss. Because of the varied factors affecting the rate of fat loss, late winter KFI values may not adequately represent the pre-breeding body condition.

The conception dates used for my condition analysis were estimated using fetal measurements based on Hamilton et al. (1985). Recent data suggests the Hamilton fetal scale may not accurately predict fetal age for all areas of Mississippi due to regional variation in birth size (A. R. Castle - Blaylock, Mississippi State University, unpublished data). However, without a more accurate fetal aging scale it would not be possible to test the conception date variations more accurately.

MANAGEMENT IMPLICATIONS

Inter-annual variation in individual conception date may be greater than originally thought and may help explain within population variation that Sumners (2004) could not explain through genetics. Because management activities often include conception date management this is an important factor for managers to understand. Large ranges of individual annual conception dates may be “normal” in southeastern deer herds; however, further assessment of individual variation in penned and wild populations could provide a better understanding of the normal distribution of conception dates. Further assessment of potential environmental cues, including a pre-breeding nutritional condition index, could provide additional clues to help managers direct attention to factors affecting conception dates.

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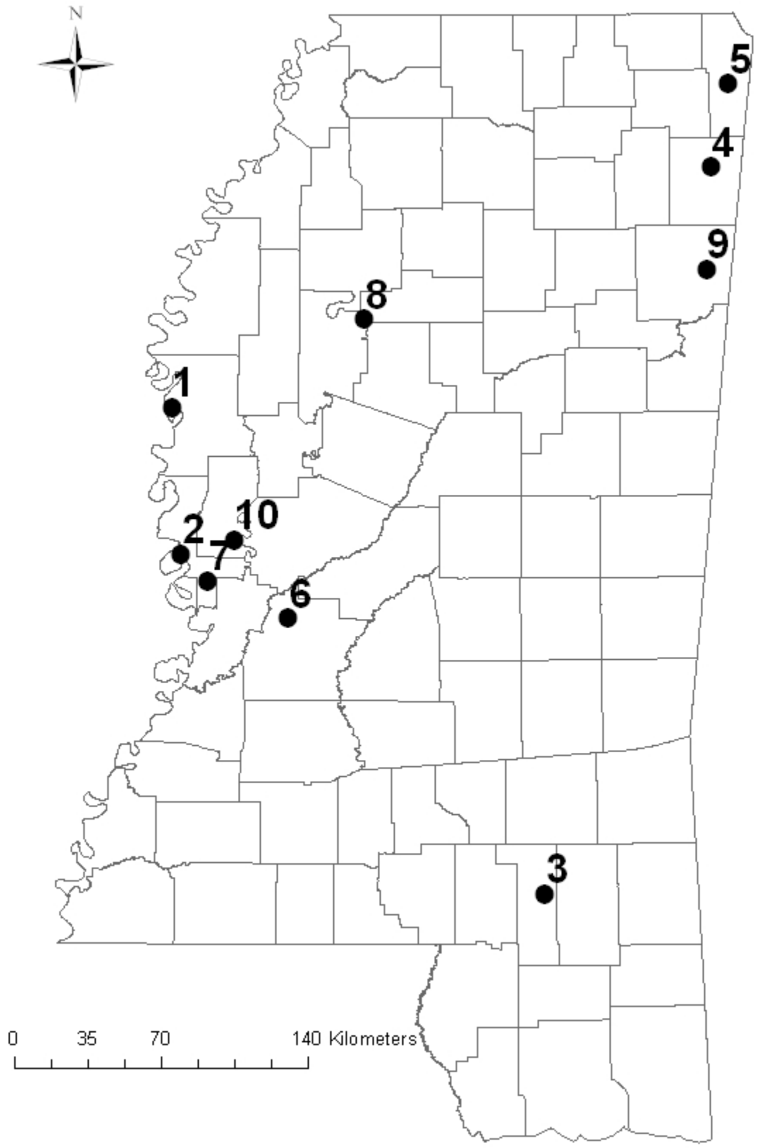

Figure 2.1. Populations within Mississippi that had at least 5 years of herd health evaluations with a minimum of 10 does collected from 1991 – 2004. The numbers correspond with populations listed in Table 2.1.

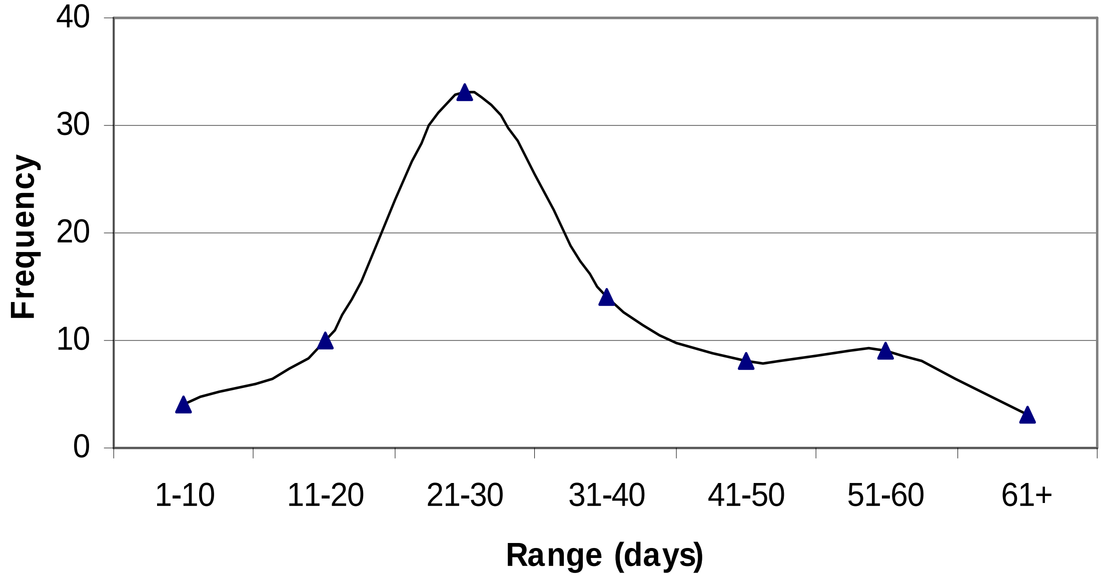

Figure 2.2. Frequency distribution of within-animal conception date ranges for 81 adult does (2 years and older) with at least 5 years of fawning data from the Kerr Wildlife Management Area and Mississippi State University deer units, 1976 to 2003.

Table 2.1. Study area location and size, number of years, number of deer (n), and mean conception date of deer collected during annual herd health evaluations in Mississippi, 1991-2004.

Area	Region	County	Hectares	Years	*n*	Conception Date	
						Mean	SE
1. Ashbrook Island	Batture	Washington	2,145	5	52	8-Dec	1.4
2. Black Bear Plantation	Delta	Issaquena	4,138	7	107	26-Dec	1.4
3. Camp Shelby	LCP[a]	Forrest	3,683	5	71	21-Jan	1.2
4. Canal Section WMA	UCP[b]	Itawamba	1,052	5	59	19-Jan	1.7
5. Divide Section WMA	UCP[b]	Tishomingo	6,206	5	59	12-Jan	1.9
6. Halifax Hunt Club	Loess	Hinds	3,426	10	124	27-Dec	1.4
7. Mahannah WMA	Delta	Issaquena	5,129	5	55	2-Jan	2.2
8. Malmaison WMA	Delta	Grenada	3,837	9	101	16-Dec	1.2
9. Monroe County East	UCP[b]	Monroe	N/A	5	86	6-Jan	2.0
10. Sunflower WMA	Delta	Yazoo	23,666	9	137	29-Dec	1.3

[a.] Lower Coastal Plain
[b] Upper Coastal Plain

Table 2.2. Julian conception date variation of 2.5 + year old does from selected white-tailed deer populations in Mississippi, 1991-2004.

Area	*n*	Years	Mean	SD	Range	Median	Range
Ashbrook Island	52	5	343	1.90	4	343	7
Black Bear Plantation	107	7	362	4.83	13	360	18
Camp Shelby	71	5	388	4.30	9	388	8
Canal Section WMA	59	5	385	3.66	10	386	5
Divide Section WMA	59	5	378	0.87	2	378	11
Halifax HC	124	10	362	4.12	13	363	18
Mahannah WMA	55	5	368	4.50	12	368	11
Malmaison WMA	101	9	352	6.87	24	352	18
Monroe Co. E.	86	5	372	5.56	15	371	10
Sunflower WMA	137	9	364	4.74	15	363	9
Overall	851	65	367	4.13	12	367	11

Table 2.3. Median days deviation from breeding date predictions based on moon phase (Alsheimer 1999) and proportions of years with directional agreement in annual shifts of moon phase and breeding date for selected white-tailed deer populations in Mississippi, 1991-2004.

Area	Years	Median Observed	Median Predicted	Median Days of Deviation	Directional Agreement Proportion
Ashbrook Island	5	343	356	12	0.00
Black Bear Plantation	7	360	351	8	0.33
Camp Shelby	5	388	356	34	1.00
Canal Section WMA	5	386	351	33	0.75
Divide Section WMA	5	378	355	28	0.25
Halifax HC	10	363	356	7	0.44
Mahannah WMA	5	368	355	13	0.25
Malmaison WMA	9	352	351	0	0.75
Monroe Co. E.	5	371	356	12	1.00
Sunflower WMA	9	363	351	14	0.75
Overall	65	366	354	16[a]	0.56[b]

[a] $H_0 \leq 8$ days (P = 0.027)
[b] $H_0 = 0.5$ (P = 0.209)

CHAPTER III

EFFECTS OF PHYSIOGRAPHIC REGION AND BODY MASS ON DOE FAWN REPRODUCTION IN MISSISSIPPI

ABSTRACT

Reproduction by doe fawns can add significantly to the annual recruitment of white-tailed deer (*Odocoileus virginianus*). Documented reproductive potential of doe fawns in Mississippi does not agree with recent data collected by the Mississippi Department of Wildlife, Fisheries and Park's (MDWFP) Deer Management Assistance Program (DMAP). To clarify these differences I examined the reproductive potential of doe fawns from three physiographic regions of Mississippi using captive-reared fawns born to wild-captured dams, wild-captured doe fawns, and harvest data. Only one of 65 doe fawns examined over 2 years showed signs of reproducing. The body mass of doe fawns raised in captivity did not differ with region of origin. Yearling lactation rates indicate that physiographic region may influence the reproductive potential of deer populations in Mississippi, and the potential recruitment is likely greater than previously reported.

INTRODUCTION

Estimates of annual recruitment are vital for effective management of wildlife populations. Reproduction by first year female white-tailed deer (*Odocoileus virginianus*) can add significantly to annual recruitment (Haugan 1975, Rhodes et al. 1986), but the contribution often varies by area.

Fawn breeding is influenced by several factors including photoperiod (Budde 1983, Verme and Ozoga 1987), nutrition (Abler et al. 1976), and density (Swihart et al. 1998). It is generally accepted that fawns must reach a critical mass to breed (Demarais et al. 2000). Critical masses of 36 and 41 kg have been identified for northern white-tailed deer and Rocky Mountain mule deer (*O. hemionus*), respectively (Moen 1973, Robinette et al. 1973); which equates to approximately 60% of total adult body mass (Moen 1973, O'Pezio and Sauer 1974). However, there have been no published reports of a critical mass for deer in the southeastern U.S.

Research in Mississippi has shown that ≤3% of fawns breed annually (Noble 1974; Jacobson et al. 1979). However, recent data from the Mississippi Department of Wildlife, Fisheries and Parks (MDWFP) Deer Management Assistance Program (DMAP) suggests fawn breeding may approach 16% in some regions (Mississippi Department of Wildlife, Fisheries and Parks 2006). Likewise, Jacobson (1992) found that yearling lactation rates increased from 6% to 22% following a reduction of density in a Mississippi deer herd which indicate greater incidence of fawn breeding than previous reports. These conflicting reports need to be clarified for future use and proper assessment of the Mississippi deer herd.

My objective was to evaluate region of origin and body mass as sources of variation in breeding success of fawns. I compared the proportions of fawns that bred during their first year based on their 3 regions of origin in Mississippi and compared these proportions to wild deer from the respective regions. I compared body mass to determine if there is a critical mass necessary for reproduction in female fawns. I hypothesized that doe fawns raised with optimum nutrition in the pens would be more likely to reproduce than wild fawns due to increased nutrition and subsequent greater body mass. I hypothesized that a greater proportion of fawns from the Delta region would reproduce due to their earlier births and expected greater body mass.

STUDY AREAS

The MDWFP captured deer from 3 physiographic regions within Mississippi as delineated by Pettry (1977; Fig.3.1). The Delta, Thin Loess, and the Lower Coastal Plain regions were selected because they represent a wide range of body masses from greater to lesser found in Mississippi (Strickland and Demarais 2000). Capture locations (Table 3.1) within each region included a mixture of public Wildlife Management Areas and private hunting clubs which are DMAP cooperators (Guynn et al.1983).

The Delta region (Delta and batture soil regions; Fig. 3.1) is characterized by relatively level land and rich alluvial soils making it a prime area for agriculture (Pettry 1977), and composes approximately 14% of the state. Because of the fertile alluvial soils this area was considered the greatest quality region for this study. Deer from the Delta region had greater eviscerated body mass for all gender and age classes than other regions of Mississippi (Strickland and Demarais 2000). They hypothesized this was due to increased nutritional quality of the forage related to the greater quality soils present in the region.

The Thin Loess region (hereafter Loess) is a narrow strip of wind deposited soils continuing from the south-western corner to the north-central area of the state and it composes approximately 14% of the state (Fig. 3.1). The upper and lower Thin Loess soil regions share similar characteristics and were grouped together for sampling. The soils of the Loess tend to be silty, and although agriculture is not as prominent as in the Delta, it composes a large percentage of the land use (Pettry 1977). The 2 to 3 kg lesser eviscerated body mass of female deer in the Loess compared to the Delta was assumed to be related to lesser soil fertility and forage quality (Strickland and Demarais 2000). The Thin Loess region was considered a mid-quality region for this study.

The Lower Coastal Plain (hereafter LCP) composes 22% of southeastern Mississippi (Pettry 1977; Fig 3.1). The soil of the Lower Coastal Plain is characterized by a mixture of sand, loam, and clay, which leads to an associated problem of nutrient leaching and lesser soil fertility (Pettry 1977). This lesser fertility and nutrient leaching could be a major factor in the lighter body mass in this region (Strickland and Demarais 2000). This region is most noted for pine (*Pinus* spp.) production, which has been associated with reduced morphometrics in white-tailed deer (Strickland 2005) because mean eviscerated body masses of female deer were 7 to 10 kg less in the Lower Coastal Plain than in the Delta region (Strickland and Demarais 2000), the LCP was considered the lesser quality region for this study.

Captured deer were housed at the Mississippi State University Rusty Dawkins Memorial Deer Unit (hereafter MSU Deer Unit). The MSU deer unit is a high-fenced research area located in the city of Starkville, Mississippi, U.S. The facility is subdivided into 11 pens ranging in size from 0.1 to 0.8 ha.

METHODS

During January-March of 2005 and 2006, the MDWFP captured 25 adult does (≥1.5 years of age) that produced doe fawns for this study from each of 3 regions (Delta, Loess, and LCP; Table 3.1). Capture dates were after breeding season, based on previous spring health check data (C. W. Dacus, Mississippi Department of Wildlife, Fisheries, and Parks, unpublished data), so I assumed mature does were pregnant at capture. In addition, during 2006, the MDWFP captured doe fawns (6-8 months of age) from these same populations and regions (Table 3.1).

We transported captured deer to the MSU deer unit where they were housed according to region. All deer had access ad libitum to 2 feeders containing 20% protein deer pellets (Purina AntlerMax Professional High Energy Breeder 59UB, Purina Mills, St. Louis, MO) in addition to planted forage such as Patriot Clover and Max Q fescue (Pennington Seed Company, Madison, GA) and natural forage such as bermuda grass (*Cynodon dactylon*), Bahia grass (*Paspalum notatum*) and native sedges (*Carex spp*).

The adult does gave birth within the confines of the MSU deer unit. We captured each fawn within the first 3 days after birth. We sexed, weighed, and uniquely marked each fawn with medium plastic ear tags (Allflex, Dallas, TX), metal ear tags (size 681, Hasco Tag Company, Dayton, KY), ear tattoos (Stone Mfg., Kansas City, MO), and a freeze brand on each rear hindquarter featuring a single digit year of birth. We collected tissue samples using ear notches so the dam of each fawn could be identified via DNA microsatellites (DeYoung et al. 2003; DNA Solutions, Oklahoma City, OK). All handling and marking techniques were approved by the Institutional Animal Care and Use Committee (Protocol 04-068).

At 5.5 months from the mean fawning date for each region we removed the adult does and male fawns from the pens and weighed the doe fawns. Wild-captured fawns were weighed, marked with large sized plastic ear tags (Allflex, Dallas, TX) and metal ear tags (size 681, Hasco Tag Company, Dayton, KY), and transported to the MSU deer unit for addition to the breeding groups. We placed a sexually mature buck (≥1.5 years of age) with the doe fawns so that any doe which came into estrus had the opportunity to be bred.

I determined pregnancy status using 3 methods. I daily monitored all treatment animals for swelling as a sign of pregnancy and looked for neonate fawns within the pens. In May 2007, I sedated does born in the pens during 2006 to sample for Pregnancy Specific Protein B (PSPB; BioTracking LLC, Moscow, ID). Wood et al. (1986) found that PSPB was 98.5% effective in pregnancy detection with white-tailed deer. Lastly, I examined the reproductive tracts of doe fawns that died during these periods for presence and numbers of fetuses and corpora lutea (CL).

To assess fawn breeding in wild populations I used data collected from MDWFP Wildlife Management Areas and DMAP cooperators (C. W. Dacus, Mississippi

Department of Wildlife, Fisheries and Parks, unpublished data) from 1993 – 2002 within the regions where deer were captured (Fig. 3.1). I used lactation rates of 1.5 year old females to estimate the natural prevalence of reproduction by fawns.

I compared effect of region on body mass at 5.5 months for 30 doe fawns born in the MSU deer unit from wild-caught dams using a one-way ANOVA. I did not include data from wild doe fawns captured during 2006 because capture dates differed among regions and would have confounded the comparison.

I tested effects of region on prevalence of doe fawn reproduction in wild populations using yearling lactation rates. I used a one-way ANOVA using the GLM procedure in SAS (SAS Institute 2004) to compare the mean annual yearling lactation rates of deer harvested on DMAP properties in the regions where deer were captured (Table 3.1). Data were normally distributed based on a Kolmogrov – Smirnov test.

RESULTS

I examined pregnancy status of 65 females exposed to a male during their first year. There were 23, 23, and 19 fawns from the Delta, Loess, and LCP regions, respectively. Pregnancy status was determined for 35 fawns using observation data only, 16 using PSPB hormone assays and observation, and 14 using fetal/CL counts.

Only one fawn showed evidence of breeding. The animal was born in the pens from a wild caught doe from the Delta region. Examination of the reproductive tract on 7 May 2007 indicated she had bred; however it appeared the pregnancy had ended. One ovary had 2 CLs present and the uterine horn on that side had obvious swelling; however, there were no fetuses present so an estimated conception date could not be determined. The CLs appeared to be degenerating based on their coloration and appearance. Her body mass at death at 9.7 months of age was 27.2 kg, compared to 24.0 kg in January at 5.6 months of age. Body mass of doe fawns born in the MSU deer unit measured at 5.5 months of age did not differ by region ($F = 0.01$, $P = 0.989$; Table 3.2).

Due to the lack of breeding among doe fawns in the pens, I was unable to compare proportions of doe fawns that bred among the 3 regions. Mean annual lactation rates of yearling does harvested on DMAP properties differed among region ($F = 9.74$, $P < 0.001$). Surprisingly, the LCP had the greatest mean annual lactation rate with 16% (SE = 0.9) followed by the Delta with 14% (SE = 0.9) and the Loess with 11% (SE = 0.6) ($P < 0.05$).

DISCUSSION

The lack of successful reproduction by the pen-raised doe fawns supports the findings of Noble (1974) and Jacobson et al. (1979) that ≤3% of doe fawns bred across Mississippi based on CL counts. Likewise, Ozoga and Verme (1982) found that doe fawns in a supplementally fed enclosure in northern Michigan failed to reach puberty; however, <5% of doe fawns in wild populations in this area of northern Michigan typically breed (Friedrich and Hill 1982).

Père David's deer (*Elaphurus davidianus*) in a small pen with high density and public visitation had a increased rate of conflict behaviors (fighting and chasing) than deer housed in a larger enclosure with lesser density and no public visitation (Li et al.

2007). They postulated the increased animal-animal and animal-people interactions caused an increased secretion of glucocorticoids in deer within the small pen. Because the deer in my study were in pens of similar size and density it is possible that similar conflicts arose over access to food, shelter, territory, and rank (Von Holst 1998). These conflicts also could have caused an increase in glucocorticoid levels which could decrease release of gonadotropic releasing hormone (GnRH) from the pituitary. Decreased levels of GnRH could decrease the secretion of luteinizing hormone (LH; Sapolsky et al. 2000), which could block ovulation.

It also is possible pen-raised fawns never reached critical mass needed for doe fawns to successfully reproduce (Demarais et al. 2000). The critical mass of doe fawns in New York was reported to be 36 kg (Moen 1973) which was 60% of total adult body mass (O'Pezio and Sauer 1974). Body mass of adult females from Mississippi were 56.4, 52.1, and 44.3 kg for the Delta, Loess and LCP, respectively (Strickland and Demarais 2000). If doe fawns need to attain 60% of their adult body mass then the critical mass for fawns would be 34, 31, and 27 kg for the Delta, Loess, and LCP, respectively. Body mass at of fawns at 5.5 months indicate that 6% (1 of 15) of Delta fawns, 10% (1 of 10) of Loess fawns, and 20% (1 of 5) of LCP fawns surpassed the predicted critical mass. However, none of the fawns which surpassed the critical mass successfully reproduced. The single doe fawn that bred was 10 kg lighter than the 60% of total adult body mass which suggests that the critical mass may be less than those previously reported for northern deer.

Body mass is most often used to describe the breeding potential of female fawns; however, several studies include reports of fawns which exceeded the apparent critical mass yet failed to successfully breed (Mueller and Sadleir 1979, Verme and Ozoga 1987). Doe fawns with greater body mass are more likely to breed (Robinette et al. 1973, Mueller and Sadleir 1979, Rhodes et al 1986, Verme and Ozoga 1987); however, it appears that mass may not be the only factor contributing to the successful reproduction of doe fawns. Verme and Ozoga (1987) suggested the fat/lean body composition influences sexual maturation in doe fawns. This could help to explain the reason why more of the fawns with above average mass failed to breed, but a fawn of average mass was able to breed. However, lack of body composition data and the limited sample size precludes a definitive conclusion.

The doe fawns captured in the wild during 2006 also failed to conceive. Because most doe fawns were captured from an intact family group it is likely maternal domination may have reduced number of fawns which bred prior to capture (Verme 1991). Verme (1991) cited a study in south Texas which found that orphaned fawns bred at a greater rate than control fawns (intact family group; Demarais et al. 1988) as evidence to suggest that maternal domination was inhibiting doe fawn reproduction. After capture, the stress induced by moving individuals from the wild into a pen may have increased adrenal progesterone which could block LH surges and thus block ovulation (Plotka et al. 1983). Furthermore, glucocorticoids released during stress events decrease hypothalamic GnRH release and decrease LH secretion which acts to inhibit ovulation in females (Sapolsky et al. 2000). Li et al. (2007) demonstrated that moving

Père David’s deer from a larger enclosure with limited human contact to a smaller one with increased human contact increased glucocorticoid levels. They postulated that a combination of limited living space, high animal density, and presence of human visitors were major factors affecting the stress response of the deer in their study. Similar potential stressors present in the MSU deer unit may have decreased the incidence of reproduction.

The consistent body mass of 5.5 month old does born in the pens differs from the regional pattern reported by Strickland and Demarais (2000), with the Delta being heaviest and the LCP the lightest. The body mass of the pen-raised fawns was less than the body mass of female fawns reported by Strickland and Demarais (2000) for the Delta and Loess regions; however, the body mass from the LCP pen-raised fawns was similar to those reported (Strickland and Demarais 2000). The lighter mass of pen-raised doe fawns may be partially attributed to the fact that harvest of fawns is discouraged on DMAP properties as an effort to protect buck fawns. Doe fawns that are harvested are more likely to be above average mass and be mistaken for an adult doe. This would bias the body mass reported in Strickland and Demarais (2000) by having a larger proportion of above average body mass fawns in the data set. The pattern of regional variation of mean body mass of wild-captured doe fawns, although not compared statistically, was similar to that reported by Strickland and Demarais (2000).

Fawn reproduction often varies with respect to region and is generally considered to be related to range quality (Demarais et al. 2000). Swihart et al. (1998) showed a strong negative relationship between density and doe fawn reproduction; at densities >35 deer/km^2 reproduction by doe fawns had ceased. The relationship with density is supported by research in Mississippi that found yearling lactation increased from 6% to 22% following a reduction of density (Jacobson 1992). These density effects are thought to be primarily due to the increased nutrition available after density was decreased.

Regional variation has been documented in several states and provinces including New York (Morton and Cheatum 1946), Missouri (Hansen et al. 1996), Michigan (Friedrich and Hill 1982), and Manitoba (Ransom 1967), with fawn reproduction rates being greater in areas with greater diet quality. My data appears to confirm this with the greater lactation rates in the Delta than the Loess. However, the greater lactation rates of the LCP are especially surprising as the LCP region is generally considered to be the lesser quality region with respect to soil fertility (Strickland and Demarais 2000). This is counter-intuitive to the traditional explanations of differential fawn reproduction (Abler et al. 1976). In addition, Jacobson (1983) found that doe fawns born after 1 August were less likely to breed than those born prior to 1 August. Because the mean fawning date of LCP fawns is 13 August (C. W. Dacus, Mississippi Department of Wildlife, Fisheries and Parks, unpublished data), doe fawns in the LCP should be the least likely to breed.

MANAGEMENT IMPLICATIONS

Doe fawn reproduction varies across the regions of Mississippi and likely occurs at a greater rate than previously reported (Noble 1974, Jacobson et al. 1979). Population management recommendations should account for the regional variation in doe fawn reproduction and should include the potential recruitment of fawns produced by does bred as fawns. The lactation data suggest doe fawn reproduction may occur at greater rates than reported previously by studies using fetal/CL counts. Due to the lack of agreement between the lactation data and fetal/CL counts further investigation is needed. Because the lactation data is hunter collected, the error associated with collection should be quantified so that biologists can have the most accurate estimate of annual recruitment. Furthermore, the greater lactation rates in the LCP should be investigated to determine if the lactation data are truly representative of the age class reproductive potential.

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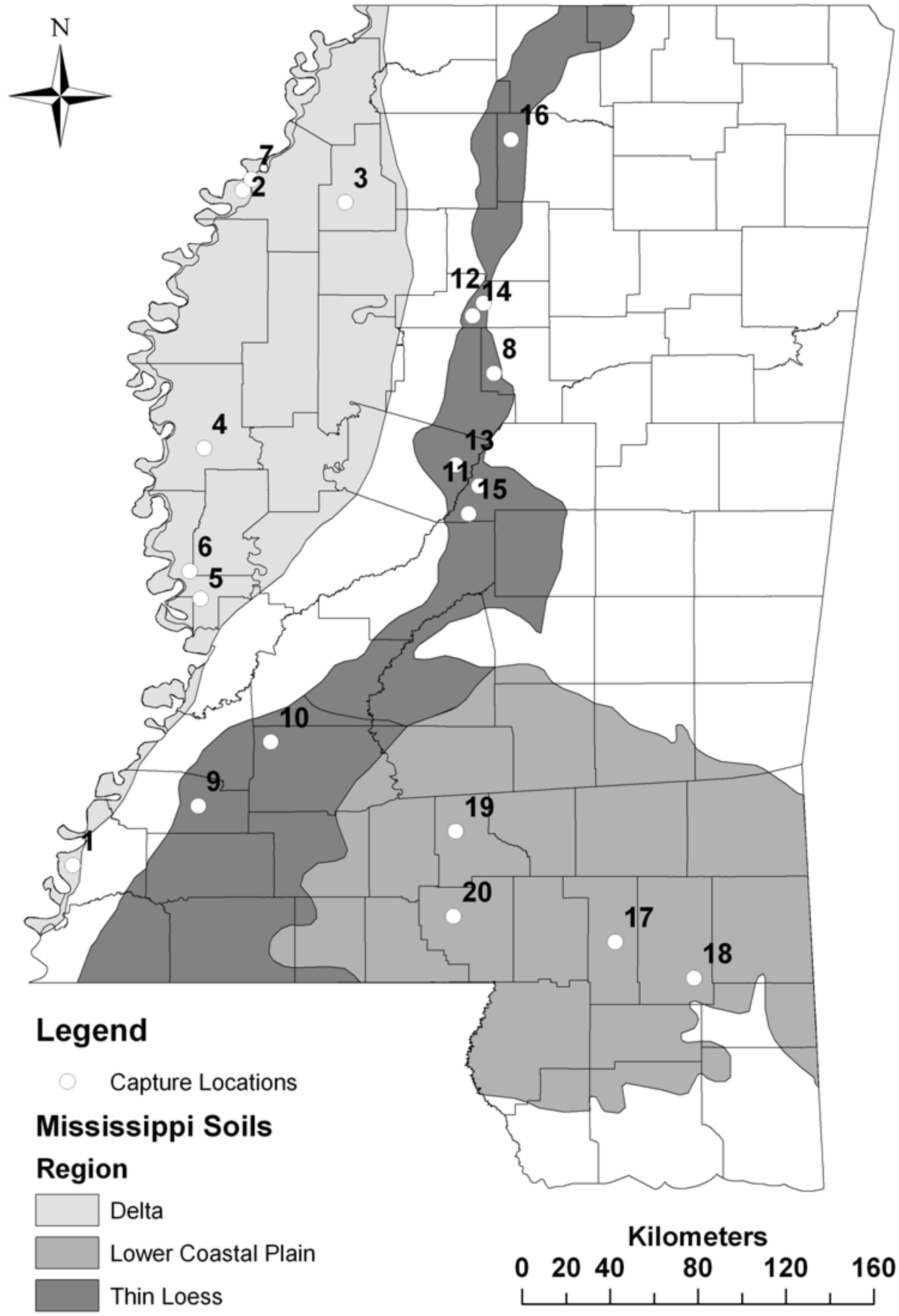

Figure 3.1. Physiographic regions of Mississippi from which bred adult does and doe fawns were captured during the winters of 2005 and 2006. Numbered capture locations coincide with study site descriptions in Table 3.1.

Table 3.1. Source, age, and body mass of adult does (≥1.5 years of age) and doe fawns (<1 year of age) captured from 3 regions[a] of Mississippi, 2005 - 2006, and the number of doe fawns produced from each source.

Site	Hectares	County	Age	Number of Fawns	Mean Body Mass (kg)
Delta					
1. Big River Farms	10,522	Adams	A	1	54.4
			J	1	36.3
2. Burkes H. C.	2,680	Coahoma	A	1	45.4
3. Info-Lab	2,657	Quitman	J	1	29.5
4. Leroy Percy S. P.	725	Washington	J	1	32.7
5. Mahannah WMA	5,129	Issaquena	A	9	55.4
6. Tennessee Bar	1,821	Issaquena	J	1	29.5
7. Ward Lake	2,590	Coahoma	A	4	62.4
			J	4	31.8
Loess					
8. Blaylock	89	Montgomery	A	2	39.9
9. Deer Creek	2,104	Jefferson	J	1	33.1
10. Deviney	404	Copiah	A	2	52.6
			J	2	28.9
11. Dr. Bryant's	526	Attala	J	1	25.0
12. Grenada Dam	313	Grenada	A	3	50.3
			J	5	27.6
13. Holmes Co. S. P.	217	Holmes	A	1	53.1
14. Hugh White S. P.	534	Grenada	A	2	39.5
			J	1	31.78
15. Riverside H. C.	1,083	Attala	J	1	28.1
16. Sardis Waterfowl	1,004	Lafayette	J	1	22.7
LCP					
17. Camp Shelby	3,683	Forrest	A	1	38.6
			J	10	22.19
18. Leaf River	16,759	Perry	A	2	44.9
19. Pace H. C.	769	Jeff Davis	J	2	26.1
20. Walker Farms	5,666	Marion	A	1	51.3
			J	2	23.8

[a.] LCP = Lower Coastal Plain soil region, Loess = Thin Loess soil region, Delta = Delta soil region.

Table 3.2. Mean live body mass (kg) of female white-tailed deer fawns at 5.5 months of age born to wild caught dams and raised in a pen, 2005-2006, doe fawns captured from wild populations during winter 2006 from 3 regions of Mississippi[a].

Source	Delta			Loess			LCP			F - Value	*P*-Value
	n	Mean	SE	*n*	Mean	SE	*n*	Mean	SE		
Pen Raised[b]	15	24.0A	1.4	10	24.3A	1.6	5	24.1A	1.7	0.01	0.989
Wild Caught	8[c]	31.9	1.1	12[d]	28.0	1.1	14[e]	23.0	0.8		

a. LCP = Lower Coastal Plain soil region, Loess = Thin Loess soil region, Delta = Delta soil region
b. Means with different letters differ ($P < 0.05$)
c. Mean capture date 29 January
d. Mean capture date 18 February
e. Mean capture date 19 March

CHAPTER IV

SYNTHESIS AND RECOMMENDATIONS

My study indicated that individual variation in conception date may be responsible for variations within populations that Sumners (2004) could not explain by genetics. Individual variation was much greater than expected and additional research is warranted to determine the causative agents. The moon phase theory (Alsheimer 1999) failed to explain these variations whereas age affected conception date of deer that bred at 1.5, 2.5, and 3.5 years of age. However, the effect of age may be confounded by the effects of primparity on gestation length. For this reason I recommend that yearling does not be included in analysis of conception date so that variations in gestation length and effects of age on conception date would be minimized.

The variation in conception dates within populations of Mississippi that I investigated varied less than others reported (Roberson and Dennett 1966, Noble 1974, Jacobson et al 1979, Rhodes et al. 1991, Jacobson 1992). Observed variation could not be explained by moon phase or late winter body condition. Evaluation of body condition effects; however, was limited due to the timing of data collection being after the fat levels began to decrease during the late winter period. If a pre-breeding condition analysis was conducted the results may have been different. Evidence suggests the genetic makeup of a population sets a general time-frame for which reproduction can occur (Sumners 2004) and smaller variations within a population are best explained by variations within individual annual conception dates.

The 65 doe fawns in my study failed to successfully reproduce. One doe conceived but she was unable to carry the conceptus to term. The doe fawn that bred was of average mass of her cohorts at 5.5 months of age. Her mass was less than the critical mass reported for northern U.S., indicating that doe fawns in Mississippi are capable of breeding at lesser weights than their northern counterparts. However, because fawns of greater body mass failed to conceive it appears that body mass may not be the sole determinant in reproduction of doe fawns. Analysis of body condition of doe fawns may provide additional clues to the factors affecting incidence of fawn reproduction

The body mass of the pen-raised fawns was less than the body mass of female fawns reported by Strickland and Demarais (2000) for the Delta and Loess regions; however, the body mass from the LCP pen-raised fawns was similar to those reported (Strickland and Demarais 2000). The lighter mass of pen-raised doe fawns may be partially attributed to the fact that harvest of fawns is discouraged on DMAP properties as an effort to protect buck fawns. Doe fawns that are harvested are more likely to be above average mass and be mistaken for an adult doe. This would bias the body mass reported in Strickland and Demarais (2000) by having a larger proportion of above average body mass fawns in the data set.

The yearling lactation rates collected from DMAP properties varied by region. Surprisingly, the lower coastal plain (LCP) fawns had the greatest lactation rates. This counters the conventional knowledge of factors affecting fawn reproduction because this region is generally of lower soil quality (Strickland and Demarais 2000) and should have a lesser incidence of fawn reproduction. Additional investigation of the lactation data could provide clues to the reason of greater lactation rates in the LCP.

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APPENDIX

TABLE OF RESULTS FOR INDIVIDUAL WHITE-TAILED DEER FROM KERR WILDLIFE MANAGEMENT AREA AND THE MISSISSIPPI STATE UNIVERSITY DEER RESEARCH UNIT

Table A.1. Breeding statistics for selected individual deer including median deviation from the predicted moon phase and the proportion of years with directional agreement in shifts of conception date and predicted moon phase from the Kerr WMA and Mississippi State University deer units and their respective conception dates and effects of moon phase 1976 – 2003.

Deer ID		Years	Mean	Std. Dev.	Range	Median Deviation	Directional Agreement
Location	Deer						
Kerr	176012	5	336	16	38	13	0.25
Kerr	176024	5	334	14	37	7	0.25
Kerr	176025	6	320	13	35	1	0.40
Kerr	176051	5	332	11	31	5	0.25
Kerr	176052	5	341	10	24	16	0.75
Kerr	177006	6	316	7	18	2	0.40
Kerr	177048	8	324	13	39	2	0.42
Kerr	177049	5	338	4	11	15	0.75
Kerr	178009	7	343	16	51	24	0.25
Kerr	178021	8	318	9	28	5	0.00
Kerr	178027	6	339	17	45	10	0.00
Kerr	179008	5	321	3	6	5	0.50
Kerr	179009	7	323	10	30	3	0.50
Kerr	179042	7	323	20	64	4	0.25
Kerr	180021	6	319	14	42	4	0.20
Kerr	180024	5	312	11	28	3	0.25
Kerr	180035	6	331	10	23	7	0.60
Kerr	180036	5	329	10	24	2	0.25
Kerr	180091	6	296	11	31	26	0.80
Kerr	182056	5	328	9	20	13	0.25
Kerr	182071	5	325	8	21	6	0.25
Kerr	182076	5	333	6	15	11	0.00
Kerr	183006	5	314	10	23	4	0.25
Kerr	183018	5	330	24	60	5	0.75
Kerr	183022	5	318	12	27	6	0.25
Kerr	183027	5	334	9	21	2	0.25
Kerr	183043	5	331	7	16	13	0.25
Kerr	183047	5	320	10	24	3	0.50
Kerr	186013	7	308	8	21	11	0.29
Kerr	186039	10	317	7	25	9	0.56
Kerr	186040	9	326	8	26	7	0.25
Kerr	186051	9	325	15	48	6	0.13
Kerr	186069	5	331	13	26	9	0.50
Kerr	186103	5	350	17	46	3	0.50
Kerr	186107	5	323	17	41	9	0.50
Kerr	187092	7	319	9	30	5	0.17
Kerr	188024	5	303	21	48	18	0.25
Kerr	188038	7	342	3	10	20	0.33
Kerr	188042	5	318	25	57	0	0.50
Kerr	188083	5	345	9	22	23	0.50
Kerr	188084	6	345	10	23	28	0.20
Kerr	189009	6	306	5	13	23	0.40
Kerr	190016	5	313	28	66	1	0.50

Table A.1 Continued

Deer ID		Years	Mean	Std. Dev.	Range	Median Deviation	Directional Agreement
Location	Deer						
Kerr	190019	7	326	21	62	15	0.33
Kerr	190050	5	301	9	22	22	0.00
Kerr	190058	5	335	7	16	14	1.00
Kerr	190077	5	322	10	25	0	0.50
Kerr	190090	8	340	9	28	18	0.71
Kerr	190118	5	299	18	35	29	0.25
Kerr	190126	7	344	13	32	25	0.67
Kerr	191004	6	335	9	22	16	0.20
Kerr	192057	7	315	17	55	14	0.67
Kerr	192061	7	322	5	14	2	0.50
Kerr	192063	6	323	4	10	1	0.40
Kerr	192078	7	331	13	41	0	0.50
Kerr	193001	5	314	9	22	6	0.75
Kerr	193012	6	312	13	29	9	0.40
Kerr	193016	6	335	14	29	3	0.00
Kerr	193026	6	333	9	24	12	0.40
Kerr	193028	5	310	23	60	14	0.75
Kerr	193032	8	327	9	21	2	0.00
Kerr	193050	6	324	6	18	4	0.20
Kerr	193051	5	302	17	37	21	0.50
Kerr	193070	6	347	8	23	25	0.60
MSU	Bambi Va	8	330	4	12.0	4	0.14
MSU	Bambi (B)	9	391	8	28	41	0.13
MSU	Candi	13	331	11	37	8	0.67
MSU	Joker	7	377	21	54	9	0.67
MSU	Lisa	8	363	12	34	5	0.71
MSU	Judy	11	367	9	28	11	0.90
MSU	Anna	7	383	13	31	27	0.50
MSU	Cindy	6	397	8	23	45	0.20
MSU	Jeannie	5	395	11	28	37	0.75
MSU	Sue	6	393	15	34	35	0.40
MSU	Bo	6	360	23	57	4	1.00
MSU	Clementine	6	379	18	44	24	0.40
MSU	Lee	8	370	19	58	24	0.43
MSU	Blondie	5	408	12	33	52	0.25
MSU	Minnie	7	357	8	22	9	0.50
MSU	Betty Crocker	5	360	2	5	10	0.50
MSU	8934	5	335	20	53	13	1.00