

ARTÍCULO DE INVESTIGACIÓN / RESEARCH ARTICLE

PREGNANCY RATE AND NUMBER OF FETUSES OF WHITE-TAILED DEER RELATED TO BODY MEASUREMENTS AND SERUM METABOLITES

Tasa de preñez y número de fetos del venado cola blanca relacionados con medidas corporales y metabolitos séricos

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ABSTRACT

This study aimed to assess the association between fertility and the number of fetuses of free-ranging concentrate-supplemented white-tailed deer (*Odocoileus virginianus*, texanus, Mearns 1898) from northern Mexico (27 °N) with body measurements and serum metabolites indicative of nutritional status. We studied 119 female deer (31 yearlings and 88 adults) captured in January 2021 using a net gun fired from a helicopter. Ultrasound scanning showed 100 and 97.8 % pregnancy rate and 1.52 ± 0.51 and 1.50 ± 0.59 fetuses/pregnant doe for yearlings and adult does, respectively, with no difference ($p > 0.05$) between age classes Thoracic circumference (cm) was higher (85.9 ± 4.9 vs. 84.1 ± 4.2 ; $p = 0.039$) for does carrying twins vs. singles. None of the serum metabolites indicative of nutritional status affected the fetal number of pregnant does. It was concluded that free-ranging white-tailed deer receiving concentrate supplementation in winter on a semi-arid rangeland has a high reproductive potential. Also, these results indicate that variation in maternal age within this population was not a significant driver of reproductive metrics of white-tailed deer. The plane of nutrition used in the present study was reflected in adequate serum metabolites indicative of nutritional status. Also, thoracic circumference may have prognostic value as a physical marker of multiple fetuses in female white-tailed deer.

Keywords: body length, litter size, serum glucose, serum urea, thoracic circumference

RESUMEN

Este estudio tuvo como objetivo evaluar la asociación entre la fertilidad y el número de fetos de venado cola blanca (*Odocoileus virginianus* texanus, Mearns 1898) en agostadero en el norte de México (27 °N) y suplementado con concentrado, con medidas corporales y metabolitos séricos indicativos del estado nutricional. Estudiamos 119 (31 de un año y 88 adultas) venadas cola blanca capturadas en enero de 2021 con una red disparada con cañón desde un helicóptero. La ecografía mostró una tasa de preñez de 100 y 97.8 % y 1.52 ± 0.51 y 1.50 ± 0.59 fetos/venada gestante para animales de un año y adultas, respectivamente, sin diferencias ($p > 0.05$) entre las clases de edad. La circunferencia torácica (cm) fue mayor (85.9 ± 4.9 vs. 84.1 ± 4.2 ; $p = 0.039$) para venadas con gestaciones múltiples que para venadas gestando un solo feto. Ninguno de los metabolitos séricos indicativos del estado nutricional afectó el número de fetos de las venadas preñadas. Concluimos que las venadas cola blanca suplementadas con concentrado en invierno en un pastizal semiárido tienen un alto potencial reproductivo. Además, estos resultados indican que la variación en la edad materna dentro de esta población no afectó las variables reproductivas del venado cola blanca. El plano de nutrición utilizado en el presente estudio se reflejó en metabolitos séricos adecuados indicativos del estado nutricional. Además, la circunferencia torácica puede tener valor como marcador físico de fetos múltiples en venadas cola blanca.

Palabras clave: circunferencia torácica, glucosa sérica, longitud del cuerpo, tamaño de la camada, urea sérica

INTRODUCTION

In northern Mexico, due to the dimensions of their antlers, there is a great demand for hunting trophies of two of the subspecies of white-tailed deer (*Odocoileus virginianus*) (Martinez and Hewitt, 1999) occurring there: the Texas white-tailed (*O. v. texanus* Mearns 1898) and the Coues white-tailed deer (*O. v. couesi*).

This situation has caused the creation of ranches involved in the conservation, management, and sustainable use of wildlife, whose attention is focused mainly on managing game species (Gallina-Tessaro *et al.*, 2009). These ranches with diversified livestock practices in northern Mexico have high economic profitability due to their hunting services (Guajardo-Quiroga and Martínez-Muñoz 2004; Retes López *et al.*, 2010). White-tailed deer reproduction has been intensively studied (Therrien *et al.*, 2008; Green *et al.*, 2017; Ayotte *et al.*, 2019) because deer management often involves adjusting deer densities to keep populations in balance with their habitat.

In arid and semi-arid rangelands, female deer are less likely to reach their maximum feed intake potential during the dry season, because of more deer grazing pastures with a finite amount of available forage (Gastelum Mendoza *et al.*, 2020). Successful diversified livestock ranches with an emphasis on white-tailed deer production are reliant on achieving high deer fertility performance, thereby allowing a high pregnancy rate and a high litter size. Thus, nutritional management has a key role to play in achieving high reproductive performance (Swihart *et al.*, 1998), and many ranches have implemented nutritional programs.

Determining pregnancy rates is important to wildlife managers for understanding and predicting population trends in free-ranging white-tailed deer relative to the habitat's carrying capacity, to determine what percentages of females are bred, and the number of fetuses per doe. This information allows for corrective management decisions to promote adequate reproductive performance (Green *et al.*, 2017).

Northern Mexico has a short history of white-tailed deer management and very limited information exists on white-tailed deer reproduction, and previous estimates of reproductive variables may not apply to the well-fed deer population (Mellado *et al.*, 2013). Therefore, additional research is warranted to offer further estimates of reproductive performance. Also, the estimation of the nutritional status of Cervidae, and blood analysis is a widely used method (Rosef *et al.* 2004; Pavlik *et al.*, 2018), but characterization of blood biochemistry variables in white-tailed deer is scarce in arid environments. To provide additional information on this subject, we examined a reference line on reproductive characteristics of female white-tailed deer on rangeland receiving concentrate supplementation in

winter. Specifically, we investigated (1) the pregnancy rate and fecundity of yearling and adult deer, and (2) the association between some body measurements and serum metabolites indicative of nutritional status, on the number of fetuses per pregnant does.

MATERIALS AND METHODS

Study area

The study was carried out in a ranch registered as dedicated to the conservation, management, and sustainable use of wildlife in northeastern Mexico (Rancho San Juan; UMA DGVS-CR-EX3133-COAH; 26°50'18.7" N and 101°02'31.2" W; Fig. 1) in January 2021. The study site has an average altitude of 430 meters above sea level. The vegetation is semi-arid rangeland (microphyll desert scrub) with an average annual temperature of 21.6 °C. The average annual rainfall is 310 mm, with most rain occurring as high-intensity thunderstorms from June to October (Ovalle-Rivera, 2019). The ranch covers 3470 ha enclosed by a deer fence. There are plenty of water troughs and feed bunks.

Deer capture, handling, and pregnancy diagnosis

Animal procedures were agreed upon and performed following the Institutional Animal Care and Use Committee of the Agrarian Autonomous University Antonio Narro (Protocol #03001-2258) and carried out following FASS (2020). Given that this study involved manipulating animals including capture, marking, blood sampling, and sonogram scanning, which caused significant distress, we just worked on available trapped deers, destined for relocation. A total of 119 Texan white-tailed deer (*O. v. texanus*) were used in the present study. Deer grazed on open rangeland (3470 ha) year-round supplemented in winter with approximately 250 g of commercial concentrate/head/day (14 % crude protein).

Supplemental feed sites were distributed across the grazing area (one feed site per one square kilometer). Supplemental roofed grain feeders were housed in a circular feed pen and normally, about 50 kg of concentrate was placed at each site every six days.

The winter capture of deer was carried out by firing a nylon net with 1.3 cm² mesh, from a helicopter (Beaver *et al.*, 2022). Deer were physically restrained and blindfolded after they were captured.

Blood samples were collected by venipuncture of the jugular vein into an evacuated sterile tube without anticoagulant (Vacutainer, Becton Dickinson, Franklin Lakes, NJ). The samples were kept chilled and allowed to clot. Blood samples were centrifuged at 1800 × g for 10 min within 1 h after sampling. The serum samples were placed in plastic vials and stored at -20°C until analysis (Rankins *et al.*, 2023).

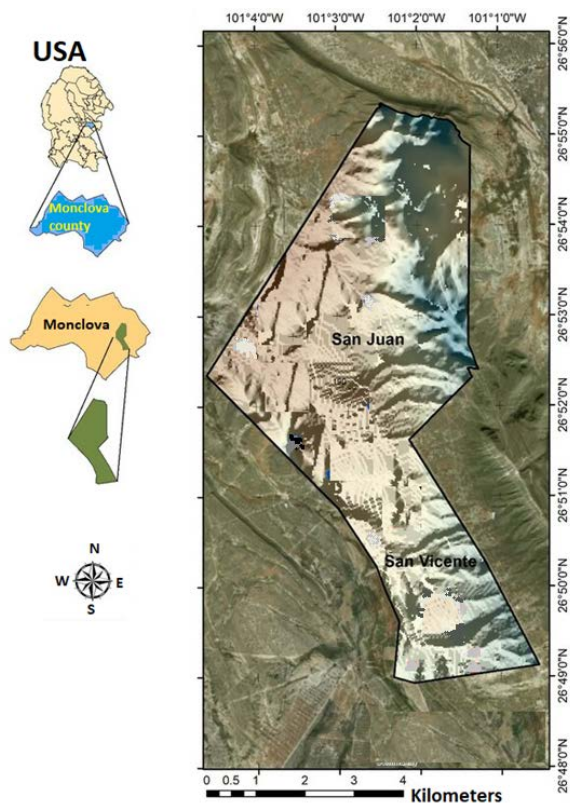


Figure 1. Map of Coahuila State, Mexico, showing the location of the study site.

Trans-rectal uterus ultrasonographic evaluations were performed using an ultrasound scanner (Aloka 500V, Corometrics Medical Systems Inc., Wallingford, CT) equipped with a linear array transrectal probe (7.5 MHz transducer) by a single experienced operator. For the scanning procedure, fecal pellets were manually removed from the rectum with deer restrained. A satisfactory amount of carboxy methyl cellulose gel was placed into the rectum to facilitate the manipulation of the probe into the rectum. The transducer was gently inserted until reaching the uterine horns, to picture the whole reproductive tract. The uterus was inspected for the presence of fetuses and the number of fetuses of pregnant does was registered (Vahtiala *et al.*, 2004).

Body, blood serum, and age measurements

Does were measured according to Uvalle-Sauceda *et al.* (2013) to the nearest 0.1 mm, by the same technician, in a standing position, firmly restrained under field conditions using a plastic measuring tape and a measuring stick. Body length was the distance between the cervicothoracic joint and the first intercoccygeal joint at the base of the tail. Front leg length was measured as a distance from the surface of the ground to the union of the leg with the chest of the animal. The thoracic circumference was measured around the chest, taking the withers as the point of reference. Age groups were separated

into yearling and older deer based on tooth eruption and wear patterns (Severinghaus, 1949). Serum glucose, total protein (TP), cholesterol, urea, and creatinine concentrations were determined using colorimetric methods following protocols supplied by the kit's manufacturers. These serum analyses were made at the laboratory of animal nutrition of the Autonomous Agrarian University Antonio Narro.

Data analysis

Principal Component Analysis was applied to reveal which variables were important to understand the sources of variation of data for single or multiple fetuses of does and see distances between important serum variables affecting several fetuses, using Statgraphics Centurion 19 (Statgraphics Technologies, Inc., The Plains, Virginia). To analyze the effect of maternal age class (yearling or mature does) on pregnancy rate, the GENMOD procedure of SAS (SAS Institute Inc., Cary, North Carolina, USA) was used. The model included the maternal age class as the potentially explanatory variable and the individual was the experimental unit. The body measurements and serum metabolites variables were compared between groups (single vs. twin pregnancy) using the GLM procedure of SAS. Variables were described as mean values \pm standard deviation, and differences between groups with 95 % confidence intervals were computed (TTEST procedure of SAS). Age category was included in the model as a covariate.

RESULTS

Rectal ultrasonographic scans indicated that 117 out of 119 experimental does were diagnosed as pregnant (98 % pregnancy rate), corresponding to the period of mid-pregnancy. The mean fetal size was 1.51 ± 0.54 (\pm SD). No differences between yearlings and older does were observed for pregnancy rate, fetuses/pregnant doe, and fetuses/total does (Table 1). Also, the percentage of does bearing singles, and twins was no different ($p > 0.05$) between yearlings and older does.

Table 1. Effect of the maternal age class of does (yearling vs. adults) on pregnancy rate, fetuses/pregnant doe, and fetuses/total does examined in concentrate-supplemented does on rangeland in northern Mexico.

Variables	Yearlings	Adults	p-value
Does examined	31	88	
Pregnancy rate (%)	100	97.8	0.27
Fetuses/pregnant doe	1.52 ± 0.51	1.50 ± 0.59	0.892
Fetuses/total does	1.52 ± 0.51	1.47 ± 0.62	0.691
Singles (%)	15/31 (48.4)	45/88 (51.1)	0.918
Twins (%)	16/31 (51.6)	42/88 (47.7)	0.709
Triplets (%)	0/0 (0%)	2/88 (2.3)	0.154

For pluriparous female white-tailed deer, one of them presented ovarian cysts and another vaginitis.

Principal components derived from some body measurements, age class, and serum metabolites, showed separation between single-bearing or twin-bearing does (Fig. 2), with thoracic circumference being the most important variable responsible for number of fetuses. The first two principal components explained 52 % of the variation in the data.

The effect of body measurements on the number of fetuses is presented in (Table 2). Only thoracic circumference was related to the number of fetuses ($p < 0.05$). None of the serum metabolite concentrations influenced the number of fetuses per pregnant doe (Table 3).

DISCUSSION

Pregnancy rate in this population of white-tailed deer was very high, as it has been reported previously (Fortín *et al.*, 2015), indicating a population in excellent health with outstanding reproductive potential due to adequate food supply (Ayotte *et al.*, 2019). Deer received supplemental concentrate in winter; therefore, they were ingesting a diet that would allow deer to meet maintenance and pregnancy nutrient requirements. No differences in pregnancy rate were observed between yearlings and adults, which agrees with Fortín *et al.* (2015). However, yearlings from larger populations have presented lower pregnancy rates and fecundity than adults (>2.5 years of age; DelGiudice *et al.*, 2007; Bender and Hoenes, 2017).

Table 2. Between-group comparison of body measurements of free-ranging female white-tailed deer bearing a single or twin pregnancy on rangeland.

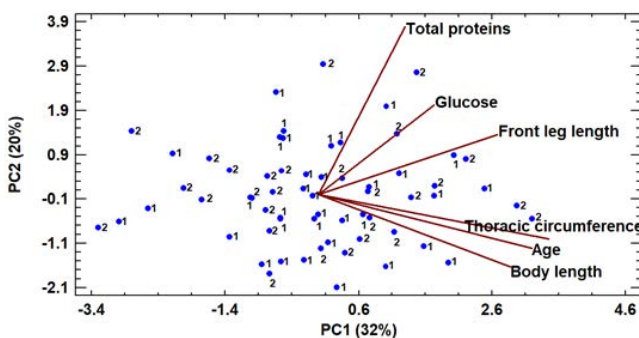


Figure 2. Results of the principal components analysis from some serum metabolites, and some body measurements. The two principal components with the largest eigenvalues are shown as the x- and y-axes, respectively. In addition, the loading for each of the input variables concerning these two dimensions is shown. For each point: 1= single, and 2= twin.

Body and age variables	Single (S; n= 61)	Twins (T; n= 60)	S-T difference 95 % CI	p-value
Thoracic circumference (cm)	84.1 ± 4.2	85.9 ± 4.9	-1.7 (-3.4 - -0.1)	0.039
Front leg length (cm)	83.7 ± 4.6	84.8 ± 5.0	-1.1 (-2.8 - 0.6)	0.211
Body length (cm)	170.9 ± 6.1	170.6 ± 6.4	0.31 (-1.9 - 2.6)	0.780
Age classes	4.0 ± 1.3	4.0 ± 1.2	0.06 (-0.4 - 0.5)	0.776

Table 3. Between-group comparison of serum metabolites of free-ranging female white-tailed deer on rangeland bearing a single or twin pregnancy.

Serum metabolites	Single (S; n= 35)	Twin (T; n= 28)	S-T difference 95 % CI	p-value
Glucose (mg/dL)	75.0 ± 28.8	76.1 ± 28.1	-1.0 (-15.4 - 13.4)	0.885
Urea (mg/dL)	26.5 ± 6.0	26.4 ± 6.2	0.15 (-3.0 - 3.3)	0.923
Creatinine (mg/dL)	2.3 ± 0.5	2.3 ± 0.4	-0.00 (-0.2 - 0.2)	0.995
Cholesterol (mg/dL)	147.7 ± 48.2	149.8 ± 44.5	-2.1 (-25.4 - 21.6)	0.863
Total proteins (mg/dL)	6.0 ± 1.1	6.2 ± 1.3	-0.2 (-0.8 - 0.4)	0.535

Pregnancy rates and litter sizes reported for free-ranging white-tailed deer in south-central New Mexico, USA were 40 % and 100 % for yearlings (1.5 years old), 95 % and 1.55 for females 2.5-7.5 years of age, and 81 % and 1.28 for females 8.5 years and older (Bender and Hoenes, 2017). In northern Mexico, the pregnancy rate was 89 % in food-supplemented females of all ages, with a mean litter size of 1.65 (Mellado *et al.*, 2013).

Pregnancy rates close to the ones observed in the present study in free-ranging deer have been reported by Tonkovich *et al.* (2004), Fortín *et al.* (2015), and DelGiudice *et al.* (2007) in habitats with high quantities of high-quality food of northern USA, but other reports including fawns, yearlings, and adults reported 65 % pregnancy rate in Midwestern USA (Haugen, 1975; Green *et al.*, 2017). The reason for this ample range of pregnancy rates is variation in habitat type and forage resource availability and quality of the diet (Millán *et al.*, 2022). Also, this discrepancy could be due to sample bias in studies with hunters' harvest, where the biggest animals are hunted, and these animals have greater odds of being pregnant (Martínez *et al.*, 2005).

The present study supported previous research that free-ranging white-tailed deer typically carry one or two fetuses (Fortín *et al.*, 2015; Green *et al.*, 2017). In disagreement with previous research where an age-related swing from producing mostly singletons at younger ages to twins in older does (Strickland *et al.*, 2008; Jones *et al.*, 2010), probably because body mass in young deer is more variable

than for older deer (Strickland *et al.*, 2008), in the present study litter size did not differ with age class. This can be explained by the fact that deer in the present study did not have nutritional limitations during the reproductive process and consequently did not present a body condition loss during the reproductive course.

Out of the four body measurements, only thoracic circumference was associated with the number of fetuses per pregnant doe. Body measurements, such as thoracic circumference have been used in the definition of adult size, nutritional status, and physiological maturity in cattle (Rocha *et al.*, 2003) and white-tailed deer (Uvalle-Sauceda *et al.*, 2013), which allow the establishment of the relationship between body conformation and functionality and length of productive life of animals (Strapák *et al.*, 2010). The thoracic circumference is related to body condition score (Tozlu Celik *et al.*, 2021) and body weight (Worku, 2019; Chay-Canul *et al.*, 2019) in sheep. Thus, apparently, in the present study greater thoracic circumference was linked with greater body energy reserves, and greater body fat of deer at about the middle of pregnancy predicted the number of fetuses they carry (Johnstone-Yellin *et al.*, 2009). Thus, thoracic circumference can provide information about the number of fetuses in pregnant white-tailed deer.

Serum chemistry results were consistent with the published literature (Smith, 2011; Chitwood *et al.*, 2013). None of the serum metabolites indicative of nutritional status were related to number of fetuses. Serum glucose, cholesterol, urea, creatinine, and total proteins are regularly included in blood chemistry profiles as metabolic indicators of physiologic condition or nutritional status and health in deer (Jenks and Leslie, 2003; DePerno *et al.*, 2015).

In ruminants, the reproductive function and endocrine system are markedly influenced by the nutrition status (Meikle *et al.*, 2018). Both over- and undernutrition not only alter body weight (Grazul-Bilska *et al.*, 2012) but also impact ovarian hormone concentrations (Scaramuzzi *et al.*, 2006), folliculogenesis, and the intrafollicular environment (Ying *et al.*, 2011; Al-Hamedawi *et al.*, 2017). In this context, the present study showed that regardless of age class, maternal nutrition of does was optimal for achieving an adequate number of fetuses.

CONCLUSIONS

Excellent maternal nutrition in winter with high levels of protein and energy in the diets of free-ranging young and adult white-tailed deer in semi-arid rangeland gave optimum pregnancy rate and fecundity. Serum metabolites indicative of nutritional status were not useful to discriminate between single or twin-bearing does, but thoracic circumference may be a usual predictor of number of fetuses in white-tailed deer. Thus, feeding on concentrate-rich diets may be feasible in droughts or when a high pregnancy rate and fecundity are desired in diversified livestock ranches in northern Mexico.

AUTHORS PARTICIPATION

Miguel Mellado designed and drafted the manuscript. Miguel Mellado and José. E. García carried out the statistical analysis. Oscar Ángel-García and Viridiana Contreras carried out the ultrasound scanning, and Jesús Mellado processed the data. Francisco Rodríguez-Huerta made the deer capture. All authors revised the manuscript and approved the submitted version.

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CONFLICT OF INTEREST

None of the authors of this article has a personal or financial relationship with other people or organizations that could inappropriately influence or bias the content of the paper.

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