v. 5, n. 3, 2025

International Journal of Biological and Natural Sciences

WHITE-TAILED DEER (*ODOCOILEUS VIRGINIANUS*) POPULATION STUDY AT THE "KAXEK" WILDLIFE CONSERVATION MANAGEMENT UNIT, YUCATAN, MEXICO

Acceptance date: 15/05/2025
Submission date: 24/04/2025

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Abstract: The objective was to estimate the population density of deer and evaluate the habitat quality of five different types, in the Management Unit for Wildlife Conservation "Kaxek" in the municipality of Buctzotz, state of Yucatan, Mexico, during the months of March and April 2017. From satellite images of the "Kaxek" property, we proceeded to geoposition linear transects, nine were installed *in situ*, with a length of 1000 m each, randomly selected. Along each transect, circular plots were placed to record the number of droppings per plot, and deer tracks were recorded along each transect. The deer population estimation was carried out using the Eberhardt and Van Etten model, and the Tyson model was used to estimate the density of deer tracks. Habitat assessment was carried out using the Habitat Unit Quality Index (HUQI) model for white-tailed deer *(Odocoileus virginianus*). The mean population estimate by excreta count was 63.7 deer/km^2, the mean population density per track was 2.46 deer/km^2. The HUQI was low in pasture habitat and medium in two types of forest and two types of acahual or secondary successional forest. It was concluded that the population density of deer is similar to other studies in forest habitats, and the habitat quality, especially the forest and acahual, presented the attributes to maintain these populations.
Keywords: acahual, habitat quality, population density, pasture, forest, white-tailed deer.

INTRODUCTION

Population estimation is the backbone of any population analysis of free-living animals. Based on the results generated, decisions can be made to make sustainable use of specimens of various species that are of economic and social importance, accordance with Mexican regulations that allow operating the binomial Conservation and Use, especially to incorporate into the legal market the commercialization of products and by-products obtained from these populations (Chamber of Deputies, 2000).

The legal extractive use of free-living specimens must be based on population estimates in the Wildlife Conservation Management Units (UMA) in Mexico, which have the authorization to do so, which must be issued by the Mexican Ministry of the Environment and Natural Resources (Cámara de Diputados, 2000).

White-tailed deer represent the most emblematic species of economic and social importance in Mexico. Because its image is taken as a symbol of social identity, for example, the coat of arms of the state of Yucatan contains the image of a deer jumping over a henequen plant. On the other hand, it is one of the most extracted species through hunting, both for subsistence and hunting. In Yucatán, Segovia *et al*. (2010) reported that temazate deer (*Mazama americana*) and white-tailed deer *(Odocoileus virginianus*) are hunted most of the year in the municipality of Tzucacab, Yucatán, by farmers and people from urban areas, which generates clandestine hunting. Montes-Pérez *et al*. (2021) reported that in the municipality of Tzucacab there is a tendency of a significant decrease in deer between 2003 and 2009, and that the probable cause is hunting. This argument is supported by another research published by Montes-Pérez *et al.* (2018) where he reports that in a conservative hunting scenario in the same municipality, around 468 deer would possibly be extracted per year.

The objective of this research was to estimate the population density of deer and evaluate the habitat quality of five different types, in the Wildlife Conservation Management Unit "Kaxek" in the municipality of Buctzotz, state of Yucatan, Mexico, during the months of March and April 2017.

MATERIALS AND METHODS

STUDY SITE

The work was carried out in the UMA Kaxek, in the municipality of Buctzotz, Yucatan State, Mexico, whose geographical coordinates are 21° 6.610' N; 88° 37.970' W. This UMA is intended to establish a model of rainwater harvesting system for planting endangered palms and is also used for planting vegetables for self-consumption and the surplus to feed backyard animals. This property has approximately 500 hectares. The climate is warm sub-humid with rain between May and July. The average annual temperature is 26.3°C. Average rainfall is 469 mm (Yucatan State Government, 2024). There are two types of native vegetation: low deciduous and medium sub evergreen forests, but there is fragmentation of the forests to establish cattle ranches and agricultural crops (Durán and García, 2010).

DEER POPULATION ESTIMATION.

The deer population monitoring was designed by tracing 12 quadrants within the property, each with an area of 41.66 ha, based on georeferenced images in Google Earth; nine quadrants were randomly selected, where linear transects of 1000 m in length each were installed *in situ*, to later record deer tracks in the same transects, the mathematical model used to estimate population density is the one modified by Tyson (Aranda, 2000).

A total of 450 plots were installed on each side of the transect, with a distance of 20 m between each one, distributed alternately in left and right position. The total area covered was 4.5 ha. The deposition time was 60 days. The defecation rate applied was 25 fecal clusters/deer, proposed by Pérez-Mejía *et al.* (2004), the model applied to estimate deer population density is that of Eberhardt and Van Etten (1956).

HABITAT QUALITY ASSESSMENT.

The Habitat Unit Quality Index (HUQI) was used. This method uses seven attributes related to the ecological requirements needed by deer populations, weighting with a higher value those that correspond to nutritional needs. The HUQI evaluation ranges from 1 to 10, which generates three categories or quality classes: Low with values from 2.0 to 4.7, Medium from 4.8 to 7.3 and High from 7.4 to 10.0, in this last category is located the habitat that satisfies most or all of the required attributes (Mandujano and Gallina, 1993).

Due to the fragmentation of the natural vegetation in the Kaxek UMA, five habitat types were classified, according to the recognition of the fundamental plant forms: herbaceous, shrub, arboreal (Meza, 2019). Key plant species were also used, they are those that serve as food for deer (Mandujano, 2008; Mandujano and Rico-Gray, 1991) as well as the percentage of leaf cover and average tree height. The habitats determined in our research are: pastures, medium sub evergreen forest, low deciduous forest, acahuales more than 10 years old (acahual + 10) and acahuales less than 10 years old (acahual 10). The acahuales are patches of native vegetation modified to establish agricultural or livestock fields that were abandoned.

The sampling units to apply the habitat classification and evaluation were the plots, which covered the five habitat types.

RESULTS

The number deer tracks in all transects was 71. Total excreta collected in the 450 plots was 349, with an average of 0.78 excreta/plot, densities obtained with each method and their 95% confidence intervals are shown in Table 1.

It is observed that the mean densities of the monitoring by means of footprint counting in transects and excreta in deer plots/km^2, are different, considering that they are different methods of population estimation.

Method	Average density (deer/km^2)	Minimum Density (deer/km^2)	Maximum Density (deer/km^2)
Footprint counting	2.46	1.52	3.67
Excreta/plot count	63.7	50.51	75.91

Table 1. Deer population densities with their 95% confidence intervals, using two estimation methods in the Kaxek UMA.

Plant species	**Habitat type**				
	Medium rainforest	Lowland rainforest	Potrero	Acahual -10	Acahual +10
Acacia cornigera (L.)	X	X	X		X
Acacia gaumeri (Blake)	X	X	X	X	X
Bursera simaruba (L.)Sarg	X	X			X
Cnidoscolus multilobus	X				
Diospyros anisandra (S.F. Blake)	X				
Gymnopodium floribundum (Rolfe)	X			X	X
Leucaena leucocephala (Lam) de Wit	X				
Abutilon gaumeri		X			
Metopium brownei		X			
Senna racemosa		X	X		X
Acacia farmesiana (L.)			X		X
Cochlospermum vitifolium				X	X
Eugenia arillaris (Swartz)				X	
Neomillspaughia emarginata(Gross)				X	
Dyospyros cuneata (Standley)					X

Table 2. List of plant species consumed by white-tailed deer by habitat type in the Kaxek UMA.

Habitat Unit	**Average plant height (m)**	**% coverage**
Potrero	1.6	1
acahual+10	3.4	23.04
acahual-10	3.4	14.44
lowland rainforest	4.1	6.52
medium rainforest	6.1	15.56

Table 3. List of the different habitats, average plant height and leaf cover in each habitat. The percentage is based on the sample space of 4.5 ha, the remaining percentage is from sites that are not available habitat for deer

Habitat Unit	**HUQI**	**HUQI* Class**	**Number of Attributes Satisfied**
Potrero	2.9	B	1 a 3
Acahual less than 10 years	4.9	M	4 a 5
Acahual more than 10 years	5.4	M	4 a 5
Lowland rainforest	4.9	M	4 a 5
Medium rainforest	5.8	M	4 a 5

Table 4. Values of the Habitat Unit Quality Index (HUQI) for each one in the Kaxek UMA. The total number of attributes analyzed is seven and the total number of classes that comprise them is three. Quality categories: High (A), Medium (M), Low (B).

The key plant species consumed by deer in each habitat type are shown in Table 2. This information is important because it allows evaluation of three HUQI attributes related to feeding characteristics.

Another important attribute is the availability of leaf cover and height of tree species, Table 3 shows the results of these attributes.

Table 4 shows the HUQI assessment values for each habitat and the corresponding quality class for each.

DISCUSSION

POPULATION DENSITY OF WHITE-TAILED DEER *(Odocoileus virginianus)*

The population densities estimated in our research are higher than those reported in several sites in southeastern Mexico, for example population densities of 1.13 ± 0.44 animals/ km^2 to 0.63 ± 0.43 animals/ km^2 have been reported by the method of excreta counting in plot in Tabasco (Contreras-Moreno *et al*., 2015). Montes-Pérez *et al*. (2021) reported densities of 4.63 ± 2.49 deer/ km^2 in the year 2003 to 2004, 0.294 ± 0.198 deer/ km^2 between 2007 to 2008, and in the year 2008 to 2009 it was 0.419 ± 0.0000085 deer/ km^2, using the same estimation method, in Tzucacab, Yucatan; however, Gonzalez-Marin *et al* (2008) reported densities of 5.5 ± 4.1 deer/ km^2 in El Eden ecological reserve in Quintana Roo, Mexico using the strip transect sighting method. The estimated population density in UMA Kaxek is similar to that of Eden, which is an ecological reserve and does not practice hunting, so it is expected that the populations would be relatively high, because predation would be exerted by natural predators and not by human activity.

In places where hunting is constant or there is no control, densities vary notably in the same site during the monitoring of several years, as reported by Montes-Pérez *et al.* (2021), this situation has also been reported by Segovia *et al.* (2010) who mention the following "The hunting pressure exerted by hunter-farmers on the populations of certain species can cause the local extinction of the species of greatest interest", with deer being the species most extracted by hunting.

An important feature to be taken into account is the nature of the population estimation method. The method of estimation by counting excreta in plots has been questioned by Núñez *et al*. (2000), who argue that in order to have a more accurate density, the ideal would be to have a more specific defecation rate for the site and seasonal period where the study is carried out. But lacking such a specific rate, the value that decreases the overestimation is taken, for this reason Pérez-Mejía *et al*. (2004), propose that the highest values recorded in the literature should be used, as we did in our research.

Mandujano (2014) analyzed the use of indirect methods to estimate the deer population, they mention that the use of footprint counting by the Tyson method should not be used, because the conditions in which it was standardized correspond to sites in the United States of America, where deer have a greater range of displacement than in Mexico, they propose a different mathematical model, where they assume the condition that the average number of times that a deer supposedly crosses the road is three in a period of 24 hours, they also mention that this assumption is not entirely reliable, to correct some bias it is required to generate the data of the crossing of animals on the transect and therefore generate the appropriate index of tracks to be applied in a new model proposed by this same author, which uses the variable "w" which is the average or effective width of the transect per season, concept that is correct, but it means that the perpendicular distances to which the sightings of deer are registered must be determined, therefore the direct me-

thod of sighting on the transect would be the method to be used; However, in jungle vegetation this method is not the best due to the low visibility of the specimens (Mandujano, 2014), so since there is no exact value in the study area, the Tyson method was applied. As there is no convergence of results with both methods, because the density with the excreta method is much higher, we assume that it probably overestimates the result; however, the density with the transect track count method, the value is close to the one reported by Contreras-Moreno *et al*. (2015) and Montes-Pérez *et al*. (2021), therefore it is credible, it is even close to that reported by González-Marín *et al*. (2008) who used the method of estimating sightings of ungulates in strip transect, which being an ecological reserve where hunting is controlled or does not exist, then the conditions are similar to the Kaxek UMA. It is necessary to monitor population densities in the long term with both methods to obtain consistent values in these time periods and also to carry out correlation or regression analyses between the two counting methods, to generate mathematical functions to determine the levels of parallelism with the estimated densities.

HABITAT UNIT QUALITY INDEX EVALUATION

In the Kaxek UMA, four of the five habitat units present average habitat quality that satisfies 4 to 5 needs out of a total of 7 that were evaluated with the HUQI method (Mandujano and Gallina, 1993), which determines that most of the habitats under study present the necessary characteristics for the adequate maintenance of white-tailed deer (*Odocoileus virginianus*) populations.

One of the main reasons for this situation where most of the habitat units present adequate conditions to satisfy the needs of the species is due, as Ambriz (2003) mentions, to the implementation of conservation strategies and integrated management of the forests and fauna. In Kaxek UMA, deforestation, hunting of animals for any purpose, and the generation of fire, without proper fire control, is prohibited, and the areas that used to be used as pastures have been intentionally abandoned in order to help them recover.

Another important point to note is the presence of 15 plant species consumed by white-tailed deer (*Odocoileus virginianus*), especially the medium forest and acahual + 10 years old habitats, which had seven and eight different species, respectively. Lowland jungle with six plant species, 10-year old acahual with five and pasture with four.

It is important to mention the nutritional quality of some forage species consumed by deer in the habitats evaluated. *Acacia gaumeri* is a native fabaceae that contains a high level of crude protein (CP) with an average of 17.5% CP (Ayala-Burgos *et al*., 2006). *Bursera simaruba* with average of 12.57% CP (Montes-Pérez *et al*., 2022) *Gymnopodium floribundum* contains between 9 and 12 % CP (Ortíz Ocampo *et al*., 2019), these three native species contain high level of CP which gives them nutritional importance to generate adequate levels of body growth and reproductive activity in combination with other nutrients such as macrominerals, vitamins, etc. (Muñoz and Canto, 2019). There are three species identified in the habitats with Medium category. It is notorious that the one with the lowest HUQI is pasture where only four species were identified, it is pertinent to mention that the acahual with more than 10 years, is where the highest percentage of coverage of species consumed by deer was presented, with 23.04%, followed by medium forest and acahual of 10 years. However, it was observed that the pasture habitat is one of the most transited by deer, since it presented a large number of tracks, only behind the acahuales.

Given this diversity of habitat units, it was found that the density of white-tailed deer *(Odocoileus virginianus*), in the Kaxek UMA, is medium to high, obtaining a large amount of excreta, which shows a good adaptability of the species to the environmental surroundings, which is congruent for this species of deer whose strategy is generalist (Brito-Ríos *et al*., 2022), therefore it has the capacity to complete its life cycle in altered habitat conditions, and can grow, reproduce and even reach old age in confinement, as long as its needs for space, shelter, nutritious food and water sources are met (Montes-Pérez and Mukul-Yerves, 2010).

It is concluded that the population density of deer is similar to other studies in jungle habitat, and the quality of habitat, especially the forest and acahual, present the levels of attributes to maintain these populations.

CONFLICT OF INTEREST

There is no conflict of interest between the authors for the publication of this document.

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