Activity patterns and use of artificial water ponds by White-tailed deer (*Odocoileus virginianus*) in western Campeche

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Artificial Water Ponds (AWP) are widely employed for preserving and managing white-tailed deer (*Odocoileus virginianus*) in arid, and tropical regions of Mexico. However, there is a significant knowledge gap concerning the impact of these AWP on white-tailed deer activity. To determine the effect of AWP on the ecological aspects of white-tailed deer, we assessed the visitation rates and activity patterns of this species in AWP and compared them with areas devoid of water such as Dirt Roads (DR) using camera traps during the dry season within the seasonal wetland region of Nicte Ha, situated in western Campeche, Mexico. The research was conducted in a highly seasonal tropical wetland area at the Nicte-Ha UMA in southwestern Campeche, México. We established set camera trap stations during the dry season of 2019, 2020, and 2021 in seven AWP and 12 DR that operated for at least 80 days and compared the white-tailed deer visitation rate (measured as the Relative Abundance Index, RAI) and activity patterns among both treatments and across the three studied years. We collected a total of 3,640 independent records of white-tailed deer (2,584 in AWP and 1,056 in DR) for three years, with a combined effort of 3,978 camera days (1,306 camera days in AWP and 2,672 in DR). Our analysis revealed that the Relative Abundance Index (RAI) was consistently higher in the AWP than the DR across the three study years. However, we examined RAI variations over the three years and observed differences in the AWP, while the DR exhibited a relatively stable pattern. In the case of the activity patterns, we observed that white-tailed deer were primarily diurnal, with a significant overlap in activity between the two treatment areas. Nonetheless, within the AWP, the species exhibited continuous daytime activity, whereas, in the PR, distinct activity peaks occurred during sunrise and sunset. The results show that the presence of AWP in Nicte Ha has important effects on the presence of white-tailed deer during the dry season since we observed that there is a higher RAI in the sites where there is AWP compared to the PR sites. In the case of activity patterns, the AWP sites maintain constant activity throughout the day compared to DR, where activity peaks associated with sunrise and sunset occur. Our results show the importance that this type of structure has for the management of the species during the dry season of the year in Nicte Ha and the potential benefits of these structures in tropical seasonal areas, especially under a scenario in which drought during the dry season may be more severe in the near future due to the global change.

Los cuerpos de agua construidos artificialmente son una estrategia ampliamente empleada para la conservación y manejo del venado cola blanca (*Odocoileus virginianus*) en regiones áridas y tropicales con estacionalidad marcada en México. Sin embargo, existe una importante laguna de conocimiento sobre el efecto que estos cuerpos de agua artificiales tienen en aspectos las poblaciones de los venados cola blanca. Para determinar la influencia del agua libre disponible en cuerpos de agua artificiales sobre aspectos ecológicos del venado de cola blanca, en la UMA Nicte Ha en Campeche, México, evaluamos las tasas de visita y los patrones de actividad de esta especie en cuerpos de agua artificiales (CAA) y los comparamos con áreas sin agua disponible como Veredas y Caminos (VC) utilizando cámaras trampa. La investigación se realizó en un humedal tropical altamente estacional ubicado en la UMA Nicte-Ha en el suroeste de Campeche, México. Establecimos estaciones de cámaras trampa durante la estación seca de 2019, 2020 y 2021 en siete CAA y 12 VC que operaron durante al menos 80 días. Comparamos la tasa de visita (medido como el Índice de Abundancia Relativa, IAR) del venado cola blanca y los patrones de actividad entre ambos tratamientos y a lo largo de los tres años estudiados. Obtuvimos 3,640 registros independientes de venado cola blanca (2,584 en CAA y 1,056 en VC) en el transcurso de tres años de trabajo, con un esfuerzo combinado de 3,978 días cámara (1,306 días cámara en CAA y 2,672 en VC). Nuestro análisis reveló que el IAR fue consistentemente más alto en el CAA en comparación con el VC durante los tres años de estudio. Sin embargo, cuando examinamos las variaciones del IAR a lo largo de los tres años, observamos diferencias en el CAA, mientras que el VC mostró un patrón relativamente estable. En el caso de los patrones de actividad, observamos que los venados de cola blanca eran principalmente diurnos, con una superposición significativa en la actividad entre las dos áreas de tratamiento. Sin embargo, dentro del CAA, la especie exhibió actividad diurna continua, mientras que en el VC, se presentaron picos de actividad durante el amanecer y el atardecer. Además, si bien el patrón de actividad se mantuvo constante durante los tres años de estudio en el CAA, hubo variaciones anuales en el VC. Los resultados muestran que la presencia de CAA en Nicte Ha tiene efectos importantes sobre la presencia de venado cola blanca durante la época seca ya que observamos que existe un mayor IAR en los sitios donde hay CAA en comparación con los sitios de VC. En el caso de los patrones de actividad, los sitios CAA mantienen una actividad constante durante todo el día en comparación con VC, donde ocurren picos de actividad asociados con el amanecer y el atardecer. Nuestros resultados muestran la importancia que este tipo de estructura tiene para el manejo de la especie durante la estación seca del año en Nicte Ha, y los beneficios potenciales de estas estructuras sobre otras unidades de manejo y vida silvestre en áreas estacionales tropicales, especialmente bajo un escenario en el que la sequía durante la estación seca podría ser más severa en el futuro cercano por efecto del cambio global.

Introduction

In México, white-tailed deer (*Odocoileus virginianus*) is one of the foremost managed species, especially in the north of the country, where it has been demonstrated that it can be a source of economically profitable exploitation, and with ample opportunities in tropical zones from the center and southeast México (Mandujano *et al.* 2019). The importance of this species in México has caused it to be one of the most studied species of ungulates, with extensive information about their reproduction, habitat, foraging patterns, and behavior (Gallina-Tessaro *et al.* 2019).

Free water (*i. e.*, water available for drinking) is a fundamental habitat feature for wildlife (Leopold 1987), essential for life processes (Ricklefs 2008) that may influence population dynamics and species distribution (Rosenstock *et al.* 1999; Simpson *et al.* 2011), which has been considered a limiting factor for many species in arid (Rautenstrauch and Krausman 1989; Cain *et al.* 2006) and seasonal environments (Mandujano and Hernández 2019). Free-standing water availability limits large herbivore populations if forage consumption does not meet water requirements, and because it helps with thermoregulation (Mogart *et al.* 2005; Simpson *et al.* 2011). For white-tailed deer, water is an essential nutrient necessary for meeting all their physiological needs, including the water lost from a deer's body through the excretion of wastes and evaporation from the respiratory tract and skin. Also, water is lost when a doe gives birth or is lactating in such a rate that a deer's health may be jeopardized if water is not replaced in less than 48 hours (Hewit 2011). Water bodies also are important for social interactions where evidence shows that white-tailed deer intraspecific contact is more likely in habitats where deer resources such as food and water are concentrated (Palmer *et al.* 2004; Kjær *et al.* 2010).

Water scarcity is a major challenge for wildlife habitats in arid and seasonal environments in North America and México. One way to address this issue is to construct Artificial Water Ponds (AWP), which are an integral component for maintaining and enhancing these habitats (Rosenstock *et al.* 1999). AWP have several purposes. Firstly, they aim to improve the performance of wildlife populations by increasing productivity, reducing mortality, and facilitating management. Secondly, they affect animal movements and distribution, which can have ecological and conservation implications (Bello *et al.* 2001; Destefano *et al.* 2000; O'Brien *et al.* 2006; Simpson *et al.* 2011). Furthermore, AWP can mitigate the loss and degradation of naturally occurring sources of free water, which are increasingly scarce and vulnerable due to climate change and human activity (Rosenstock *et al.* 1999; Simpson *et al.* 2011; Larsen *et al.* 2012).

The importance of water developments for white-tailed deer populations in México has been mostly studied in the north of the country (see Gallina-Tessaro *et al.* 2019 for a review). However, in the south, there is little information about this subject. Most of the water developments in this region are employed in protected areas (Borjes-Zapata *et al.* 2020) and Wildlife Management and Conservation Units (UMA per its Spanish initials; Treviño-Ruiz 2010; Gastelum-Mendoza *et al.* 2014). One of these UMAs is Nicte Ha, located in western Campeche. This UMA covers 2300 ha and has the objective of preserving and practicing legal hunting of white-tailed deer. Nicte Ha is the home of an extensive wetland system that undergoes severe seasonal changes. It has a marked dry season with temperatures above 40 °C (INEGI 2013), which contrasts with an extended flooding season that can last for more than eight months (Rivera-Arriaga and Villalobos-Zapata 2005). These climatic conditions strongly affect the resource availability for the wildlife inhabiting the area (Hidalgo- Mihart *et al.* 2017). To reduce the effect of the dry conditions in the Nicte Ha UMA, AWP were constructed along the property to preserve free water for wildlife. This is the UMA's most important habitat management activity to cope with the extremely harsh conditions during the dry season.

Many studies agree that the conservation of natural, free water sources and the construction of artificial water reservoirs are valuable strategies for wildlife conservation and management, not only in arid climate areas but also in areas with contrasting high seasonality (Martínez-Kú *et al.* 2008; Delgado-Martínez *et al.* 2018; Mandujano and Hernández 2019; Borges-Zapata *et al.* 2020). Previous studies in Nicte Ha reported that the white-tailed deer responds to these contrasting environmental conditions by increasing the daily distances traveled and home range during the harshest portion of the dry season compared to the rainy season (Contreras-Moreno *et al.* 2019a; Contreras-Moreno *et al.* 2021). Additionally, it has been found that fawning synchronizes with the dry months (February- June) of the year, and the area's seasonality is one of its possible causes (Contreras-Moreno *et al.* 2019b).

Previous work in the Nicte Ha area showed that white-tailed deer responded to the AWP, concentrating their home ranges along these free water sources (Contreras-Moreno *et al.* 2021). However, to understand how the white-tailed deer is affected by the presence of AWP in Nicte Ha, it is necessary to determine other aspects, such as the visitation rate and activity patterns in these artificial water sources and in areas where the structures are not present.

White-tailed deer use the available habitats to satisfy basic requirements for food, rumination, movement, social interactions, and rest. The resulting time budget and habitat use pattern may vary with age, sex, time of day, season, weather conditions (Beier and McCullough 1990), predators, and human activities (Kilgo *et al.* 1998). For these reasons, the aim of this research was to describe the activity patterns and visitation rate of white-tailed deer within AWP and dirt Roads using camera traps during the dry season in the seasonal wetland area Nicte Ha, Campeche, México, and how these aspects vary across three studied years (2019, 2020, and 2021). This study will contribute to understanding the behavior of white-tailed deer in the presence of artificial water sources in tropical areas with high seasonality.

White-tailed deer use the available habitats to satisfy basic requirements for food, rumination, movement, social interactions, and rest. However, these requirements may vary depending on several factors, such as age, sex, time of day, season, weather conditions (Beier and McCullough 1990), predators, and human activities (Kilgo *et al.* 1998). For these reasons, the aim of this research was to describe the activity patterns and visitation rate of white-tailed deer within AWP and pathways/trails using camera traps during the dry season in the seasonal wetland area Nicte Ha, Campeche, México and how these aspects vary across three studied years (2019, 2020, and 2021). Our study will contribute to understanding how white-tailed deer adapt to the presence of artificial water sources in tropical areas with high seasonality. This knowledge could help to improve the management and conservation of this species and its habitat.

Materials and methods

Our research was conducted at the Nicte-Ha UMA, located in southwestern Campeche, México (91° 43′ 56″ W, 18° 19′ 56″ N) adjacent to the Laguna de Términos Flora and Fauna Protected Area (Figure 1). The UMA has 2,300 ha of tropical lower coastal plain habitat situated between -1 and 3 m asl. The climate in the region is warm-humid, with a mean temperature of 27 °C and up to 2,000 mm of precipitation per year (INEGI 2013). The vegetation type of the area varies from hydrophilic vegetation, flooded savannas, mangroves, sub-evergreen flooded rain forests, tropical deciduous flooded forests, secondary growth forests, agricultural areas, and induced grasslands for cattle grazing (Ocaña and Lot 1996). In 2010, the owners of Nicte-Ha removed cattle from the ranch, and since then, the area has been exclusively used for sustainable white-tailed deer hunting. Human activity in the UMA is very reduced and consists of sporadic surveillance surveys, yearly road maintenance, and, during hunting season, intermittent hunting parties of no more than two or three persons per month.

Water availability is a key factor for wild ungulates in the Yucatán Peninsula, especially during the dry season (Reyna-Hurtado *et al.* 2010). In Nicte-Ha, a seasonal wetland area, precipitation is concentrated in a single season that usually spans from June to November. This is followed by a dry season that lasts around six months (December-May). The intensity and seasonality of the rains, combined with flat terrain, produce seasonal floods that can reach 0.5 m. The flood lasts for the entire rainy season, but once it is over, water for ungulates remains available but concentrated in numerous puddles within the area that usually dry out by mid-February. After this date, the only sources of water in Nicte Ha are the Rio del Este River and the eight AWPs constructed by the owners. It is important to note that although the Rio del Este is a permanent water body it is hardly accessible for the deer that live far from the river edges. Contreras-Moreno *et al.* (2019a, 2021) observed that in extreme cases when the AWP dry up, the individuals make long excursions of one or two days in which they travel several kilometers to obtain water from the river, returning immediately to their established home ranges inland.

AWPs were excavated with a bulldozer in 2010 and 2011 and initially consisted of a large hole approximately 15 m long, 8 m wide, and 2 m deep in the central part of the pond. The water ponds naturally fill with water during the rainy season and usually maintain water until the end of the dry season. However, in some extreme cases, some water ponds may dry up during the dry season. After the construction, the water ponds have not been excavated again, and because of sedimentation, the ponds have lost depth over the years. Currently, the AWP are surrounded by natural vegetation.

To determine the activity patterns and use of the AWP and Dirt Road (DR) treatments by white-tailed deer during the dry season of 2019, 2020, and 2021, we set camera trap stations at 7 AWP and at 12 sites along DR in Nicte Ha (Figure 1). The camera trap stations consisted of 1 or 2 cameras operated for at least 80 days. However, we could not maintain operating the cameras for this long due to equipment malfunction and theft on several occasions. We intended the separation between camera trap stations to be at least 1 km. However, this was not possible in some cases due to the distance in which some AWPs are distributed on the property. The camera traps were tied to trees at 50 cm above ground and programmed to function 24 hours a day. We obtained the number of white-tailed deer independent photographs at each camera trap station. We considered a record to be independent if the time interval between the photographs was more than 60 minutes (Tobler *et al.* 2008). We obtained the sampling effort per camera station by adding the number of camera days (*i. e.*, a period of 24 h during which the camera station was operating), from the date when the camera was first active to the date of the last photograph, for every year and all the years together. The total sampling effort AWP and DR was obtained by adding the number of camera days each camera operated on each site each studied year. We identified the hour from each white-tailed deer independent record obtained from each one of the per year. We only use independent records for the analysis (Monroy-Vilchis *et al.* 2011).

We estimated the Relative Abundance Index (RAI) for each treatment per year as a measure of visitation rate (O'Brien 2011). RAI was obtained by dividing the total number of independent white-tailed deer records per camera trap per year by the camera trap effort in each station for each site per year. We used the Wilcoxon rank sums test to compare the observed RAI per camera trap station at AWS and DR for each studied year (Siegel and Castellan 1995). We compared the RAI for each camera trap station between years for each treatment using a Kruskal-Wallis test to determine if there were differences in the visit rates derived from the environmental conditions of each year. Dunns pairwise multiple comparisons test was used in case of significant differences were found in the Kruskal-Wallis analysis (Siegel

and Castellan 1995). All our analyses were considered significant if $P < 0.05$.

We used a Kernel density estimator (Ridout and Linkie 2009) to generate the activity patterns of the white-tailed deer for each treatment and year. We also pooled all the records from the three studied years to generate a general activity pattern of the species in each treatment. To compare the white-tailed deer activity patterns between the 2 treatments and among each one of the studied years, we compared the treatment pairs per year and with the pooled data (AWP of year 2019 vs. DR of year 2019; AWP of year 2020 vs. DR of year 2020; AWP of year 2021 vs. DR of year 2021; AWP of the three summed years vs. DR of the three summed years) using the R-package overlap (Meredith and Ridout 2014). We calculated the overlap coefficient (Δ) with estimated 95% confidence intervals (CI) using a bootstrap of 1,000 samples. Following Meredith and Ridout (2014), if the smallest sample has less than 50 photographic records, we use the Δ_1 estimator. Otherwise, we used the value of Δ_4 as the overlap output. The estimated overlap coefficient can range from 0 (no overlap) to 1 (complete overlap). Activity was classified as (1) diurnal, 1 h after sunrise to 1 h before sunset; (2) nocturnal, 1 h after sunset to 1 h before sunrise; and (3) crepuscular, 1 h before and after sunrise and sunset (Foster *et al.* 2013).

Results

During the 3 years, we obtained 3,640 independent white-tailed deer records (2,584 in AWP and 1,056 in DR; Table 1) with a total camera trap effort of 3,978 camera days (1,306 camera days in AWP and 2672 in DR). The number of operating cameras in each treatment varied between years due to equipment malfunction or theft (Table 1). We obtained 1,580 records for the year 2019, 1,290 records for 2020, and 770 records for the year 2021 (Table 1)

The RAI was bigger in the AWP than DR among the 3 studied years (Figure 2; 2019: W = 6, N = 18, $P < 0.01$; 2020: W = 0, N = 15; $P < 0.01$; 2021: W = 10, N = 17, $P = 0.013$). We found differences when we compared the observed RAI in the AWP among the studied years (Kruskal-Wallis H = 7.38,
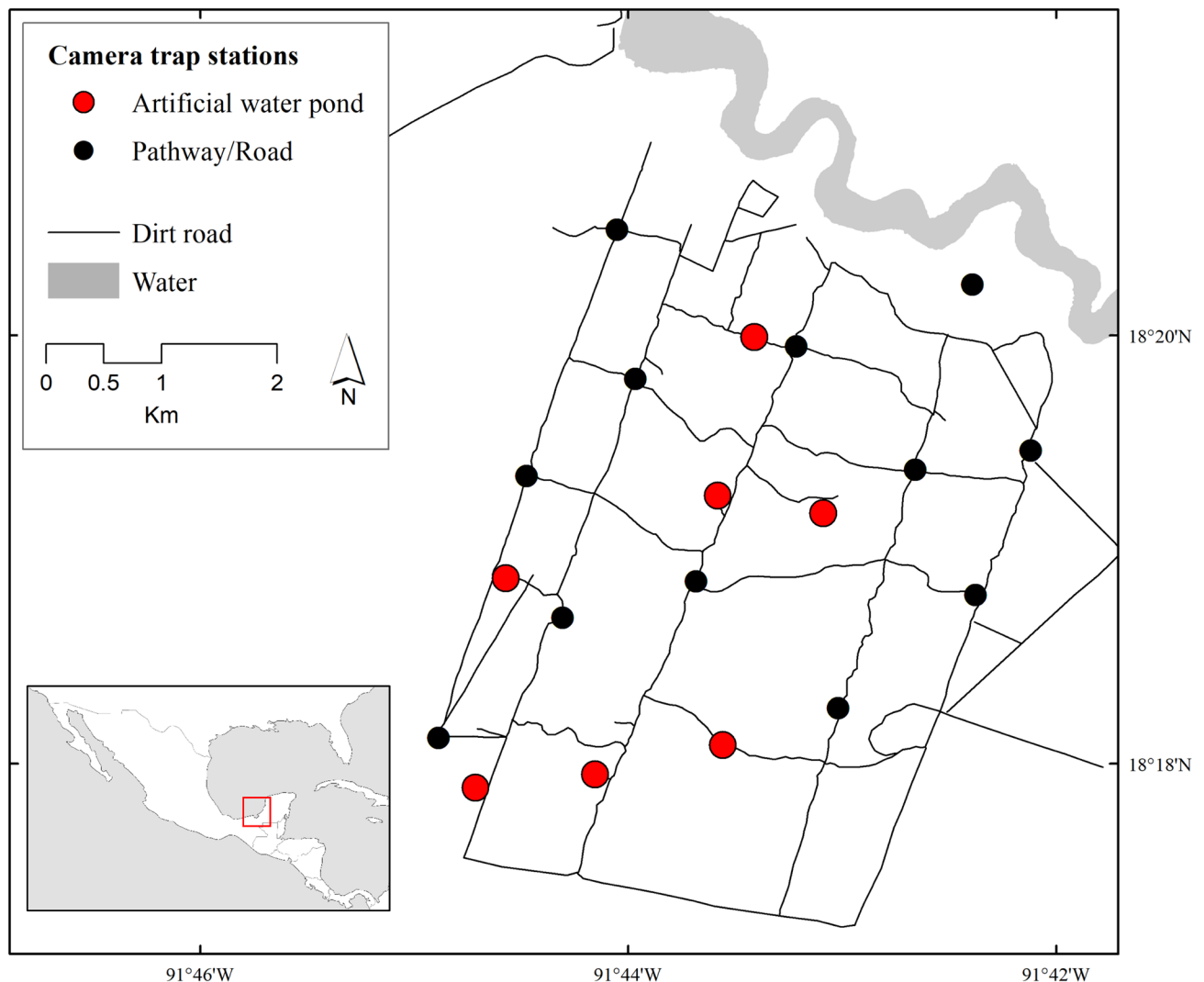

Figure 1. Location of the camera trap stations in the Artificial water ponds and the dirt roads during the dry seasons of 2019, 2020, and 2021 in the UMA Nicte Ha in Campeche, México.

Table 1. Number of white-tailed deer independent records, number of operating camera trap stations and camera trap effort in artificial water ponds and dirt roads located in the seasonal wetland obtained in 2019, 2020, and 2021 in Nicte Ha, Campeche, Mexico.

Year	Treatment	Number of records	Number of operating camera trap stations	Camera trap effort
2019				
	Artificial water pond	1,079	6	435
	Dirt Road	501	12	884
2020				
	Artificial water pond	944	4	308
	Dirt Road	346	11	953
2021				
	Artificial water pond	561	7	563
	Dirt Road	209	11	835
All years combined				
	Artificial water pond	2,584	7	1,306
	Dirt Road	1,056	12	2,672

d. f. = 2, *P* =0.02; Figure 3). Dunn's test results showed differences between the RAI of AWP in 2021 with the RAI in 2019 and 2020 (2019-2021: *P* = 0.042; 2020-2021: *P* = 0.013). However, we did not find differences between 2019 and 2020 RAI (*P* = 0.56). In the case of the RAI, among years in the DR, we found that the RAI was similar among the studied years (Kruskal-Wallis H = 4.17, *d.f.* = 2, *P* = 0.12; Figure 3).

When we pooled the 3 studied years, we found that the mean activity overlaps between both treatments was Δ = 0.885 (Δ CI = 0.853-0.916; Figure 3). In the case of the indi-

Figure 2. Comparison of the Relative abundance index (RAI) of white-tailed deer obtained in Artificial Water Ponds (AWP) and Dirt Roads (DR) during the dry season 2019, 2020, and 2019 in the UMA Nicte Ha in Campeche, México. The median of the RAI is shown as a line dividing the square, and mustaches represent confidence intervals of 95 %.

vidual years, we found that the mean activity overlap was Δ = 0.806 in 2019 (Δ CI = 0.762-0.854; Figure 4), Δ = 0.802 in 2020 (Δ CI = 0.745-0.851; Figure 3) and Δ =0.791 in 2021 (Δ CI = 0.726-0.851; Figure 4). Despite the significant overlap between both treatments, we observed in Figure 4 that in the years 2019 and 2020, as well as in the pooled data, in the case of the DR, there is a clear peak of activity at sunset compared to the AWP data, in which the white-tailed deer activity remains very similar throughout the day. Likewise, in these same years, the activity at sunset is lower in DR sites compared to AWP. In 2021, contrary to what was observed in 2019 and 2021, we observed that there is no peak of activity in the DR during sunrise, but it occurs at sunset. In the case of the AWP, it is observed that the activity is maintained mainly during the day and night, but although small peaks are observed at sunrise and sunset, these are not as marked as those that occur in the DR.

Discussion

The results show that the visitation rate of AWP in Nicte Ha has important effects on the presence of white-tailed deer during the dry season because we observed a higher RAI in the sites where there is AWP compared to the DR sites. In the case of activity patterns, white-tailed deer maintain constant activity throughout the day in AWP compared to DR, where activity peaks associated with sunrise and sunset occur.

Montalvo *et al.* (2019), in the tropical dry forest of Santa Rosa, Costa Rica, found that white-tailed deer during the dry season were found equally frequently at waterholes and roads; nevertheless, the species showed some dependency on waterholes. Contrary to this finding, in our study, over the three studied years, white-tailed deer RAI was higher in AWP compared to DR. In Santa Rosa, the lack of selection for waterholes was attributed to a strategy to avoid predation (Montalvo *et al.* 2019). In Nicte Ha, potential white-tailed deer predators such as jaguars are common (Hidalgo-Mihart *et al.* 2019). It is possible that higher temperatures that occur in Nicte Ha (higher than 40°C; INEGI 2013) compared with temperatures occurring in Santa Rosa
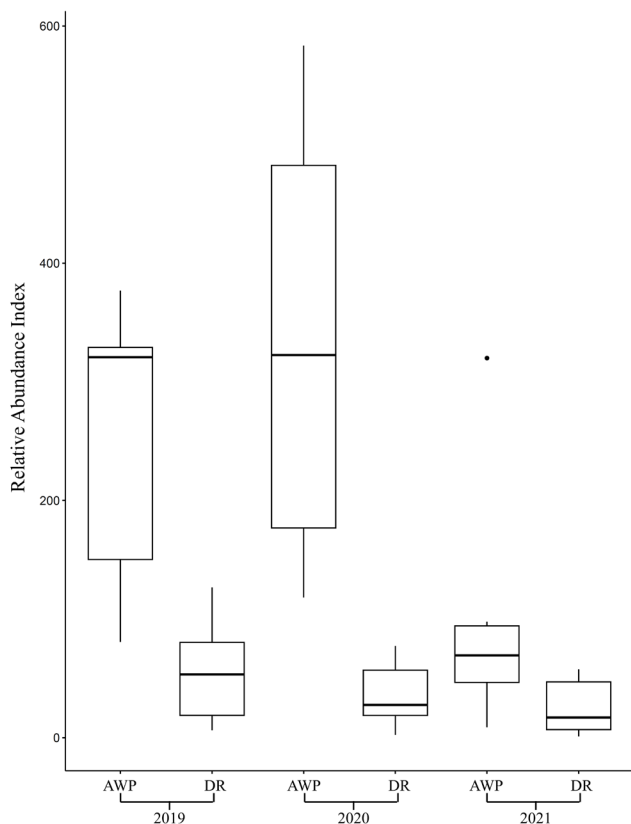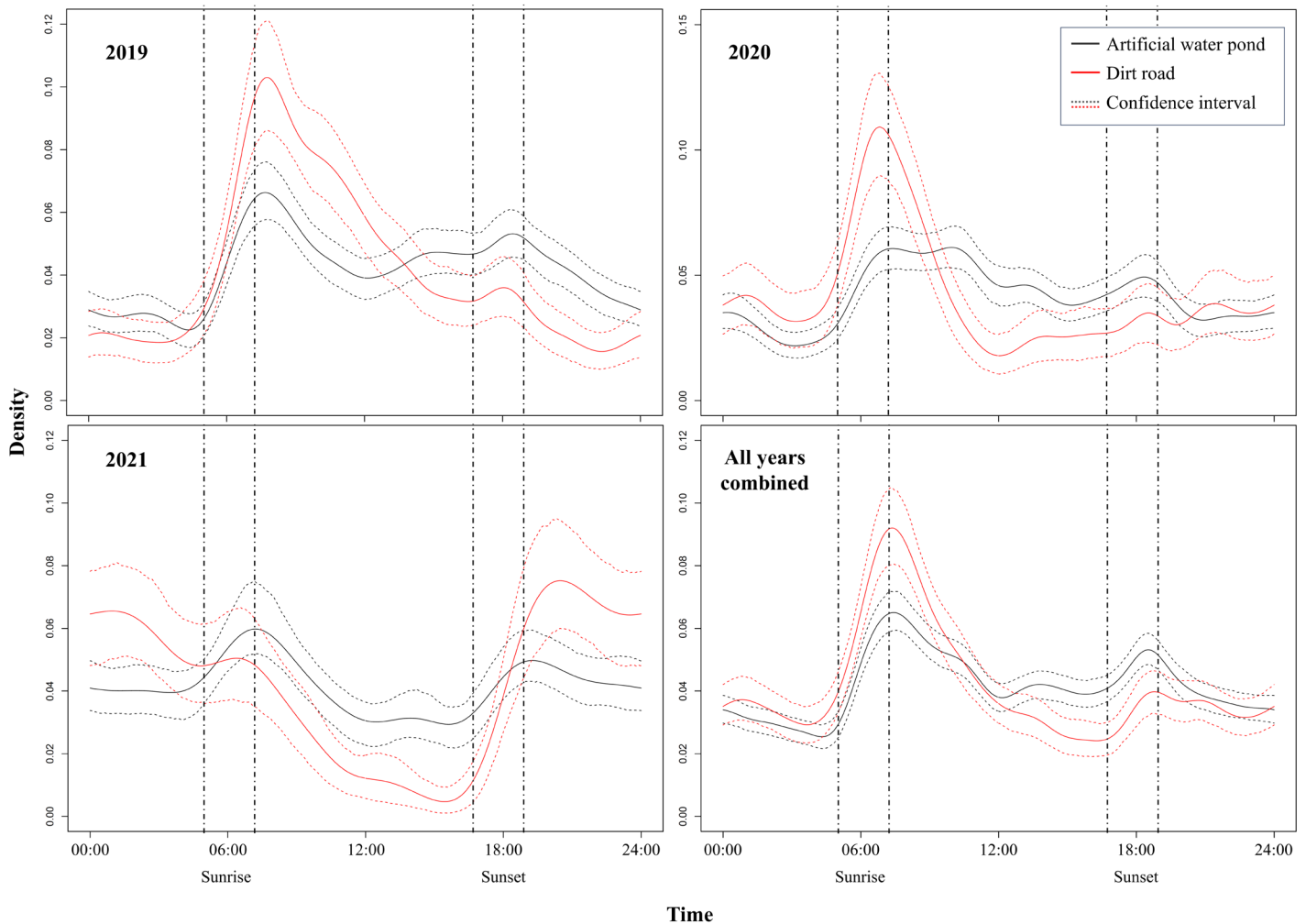
Figure 3. Activity patterns of white-tailed deer recorded in Artificial Water Ponds and Pathways/Roads during the 2019, 2020, and 2021 dry seasons in the UMA Nicte Ha, Campeche, México. Pairwise comparisons of activity overlap and 95 % Confidence Intervals of both treatments (Artificial Water Ponds and Dirt Roads) per year are shown with the identity of each activity pattern for each treatment indicated by color. Vertical dashed lines indicate sunrise (±1 h) and sunset (±1 h).

(37°C: Montalvo _et al._ 2019) could promote dehydration and the need for more water intake (Fuller _et al._ 2014), and therefore more dependency on free water for the white-tailed deer in Nicte Ha.

The white-tailed deer in Nicte Ha were followed as part of a study of home ranges, showing an important association with the AWPs during the dry season. In those cases where the AWPs dried up, they made long exploratory trips to natural water bodies such as the Rio del Este, which usually take one or two days and immediately return to their home ranges (Contreras-Moreno _et al._ 2019a; 2021). This observation would indicate that it is likely that the visitation rate recorded in the AWP areas would be higher than in other sites, as was the case with our results. However, as reported by Contreras-Moreno _et al._ (2021), the capture of the radio-tracked deer was in the AWP, so many of the results reported by them are possible, and the link of the deer to the watering holes could be an effect of the territoriality of the captured organisms and overestimate the importance of AWP on the habitat use by the species. The present study, where we obtain higher RAI in the AWP compared with the

DR, supports the idea that white-tailed deer use AWP much more than other areas of the UMA, showing the importance that this type of structure has for the management of the species during the dry season of the year in Nicte Ha.

We observed a significant overlap in the activity pattern between deer in the AWP and DR (between 70 and 85 %, depending on the year). Likewise, we observed that at least in 2019 and 2020, despite the high level of overlap, there was a peak of activity near dawn. It has been observed that, in general, deer in dry and tropical areas of México tend to be more active in the morning than in the afternoon (Mandujano and Hernández 2019; Hernández-SaintMartín _et al._ 2013), derived from the fact that it is at this time that temperatures are lower compared to the temperatures that could appear during the day and particularly during the afternoon. Thus, the deer found in the DRs could be repeating this pattern to reduce the negative impacts of high daytime temperatures, reducing the need for water intake, which must be streamlined since it does not have an available free water source. In the case of the AWP, it is noticeable that there were no clear activity peaks, and the

deer could drink water throughout the day regardless of the hour of the day and the thermal conditions. The presence of a free water source probably reduces the stress associated with water loss from high temperatures, reducing the need to adjust their activity patterns to the coolest hours of the day, such as dawn and morning.

We observed that there are differences between years in the daily activity of white-tailed deer throughout periods in which the day was divided (nocturnal, diurnal, and sunset) in the DR, while in the case of the AWP, the percentages of activity were similar throughout the three years studied. This result indicates the importance that the AWP can have since the annual environmental variations of temperature and drought that affect the deer in the DR, modifying their activities, do not affect them like those inhabiting the AWP, owing to more stable conditions. This result is important in understanding how the white-tailed deer could be affected by changes already occurring in the region. The Nicte-Ha area is anticipated to suffer a general decrease in mean precipitation and an increase in drought (Imbach *et al.* 2012; Chiabai 2015). This will probably severely impact the white-tailed deer, as has already been detected in ungulates from the Amazon basin, where extreme drought and flooding are already occurring (Bodmer *et al.* 2014). In this sense, the results of stability during the three studied years in the activity patterns derived from the presence of AWP could reduce the effect of anticipated dry conditions that could affect Nicte Ha in the future.

AWPs are one of the most common strategies made in Campeche to improve wildlife habitat along with reforestation, vigilance, wildlife monitoring, signalization, and opening fire breaks (García-Marmolejo *et al.* 2008). The results of this work are the first evaluation of the ecological effects of AWP in this area of southern México and indicate the significant effects of these structures on aspects such as visitation rate and activity patterns. However, it is essential to evaluate the long-term effects of these structures on white-tailed deer and other species, especially under the controversy surrounding the importance and impact of these AWP in supporting wildlife populations (Simpson *et al.* 2011). Undesirable effects such as the wildlife distribution patterns constriction produced by the availability of free water causing local wildlife population declines due to forage scarcity associated with over-grazing, increased predation on specific species, or reduction in water quality due to excess of organic waste, and the increased risk of disease transmission should be carefully monitored (Marshal *et al.* 2006; Simpson *et al.* 2011; Griffis-Kyle *et al.* 2014).

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