THERYA, 2022, Vol. 13(3):307-314 DOI:10.12933/therya-22-1107 ISSN 2007-3364

Native and no-native herbivorous relationships have mutual benefit: *Lepus flavigularis* case

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Lepus flavigularis is an endemic leporid from southeastern Oaxaca, México, listed as "endangered" under Mexican law and the IUCN Red List. The main threat to the species is severe habitat fragmentation due to human activities. The jackrabbit shares the grasslands with cattle (*Bos taurus*), but the trophic interaction between these herbivores is unknown. This study aimed to determine the seasonal diet of *Lepus flavigularis* and cattle, to identify the possible dietary overlap between these mammals. The study zone covers an area around the locality of Santa María del Mar in Oaxaca, southern México. Plant species were identified using linear transects, and vegetation cover was also estimated using circular plots. Throughout the study fresh *L. flavigularis* and *B. taurus* fecal samples were collected, which were processed using the microhistological technique to determine the seasonal botanical composition of diets from the two species. Twenty-three plant species were recorded in the diet of *L. flavigularis* and 29 species in the diet of *B. taurus*. Both herbivores fed primarily on Poaceae species throughout the year (*L. flavigularis*: dry season (ds) = 79.79 %, wet season (ws) = 91.54 %; *B. taurus*: ds = 78.02 %, ws = 84.63 %) despite the significant difference in the availability of plant species between seasons. No significant differences were found in the seasonal composition of the diet between the two species. Twelve plant species were consumed by both herbivores during the two seasons. The dietary overlap between the two species was high for both seasons (ds O_{jk} = 0.7311, ws O_{jk} = 0.8459). Trophic niche breadth was low for both species, with a high dietary overlap. We recorded low seasonal use values for *L. flavigularis* and *B. taurus* when compared to forage availability. Low trophic niche breadth and high dietary overlap between the two herbivores suggest forage resources competition. However, we expect that jackrabbits benefit from cattle presence, as long as the stocking rate does not increase. Furthermore, *B. taurus* grazing reduces height, cover, and density of vegetation, which could help *L. flavigularis* to avoid predators.

Lepus flavigularis es un lepórido del sureste de Oaxaca, México, categorizado como "en peligro de extinción" de acuerdo con la legislación mexicana y con la Lista Roja de la UICN. La principal amenaza para la especie es la severa fragmentación del hábitat a causa de las actividades humanas. La liebre comparte los pastizales con ganado vacuno (*Bos taurus*), pero la interacción trófica entre estos herbívoros se desconoce. Este estudio tuvo como objetivo determinar la dieta estacional de *L. flavigularis* y el ganado, así como identificar la posible superposición alimenticia entre estos mamíferos. La zona de estudio cubre un área alrededor de la localidad de Santa María del Mar en Oaxaca, al sur de México. Las especies de plantas se identificaron utilizando transectos lineales, y se estimó la cobertura vegetal utilizando parcelas circulares. A lo largo del estudio se colectaron muestras fecales frescas de ambas especies, las cuales fueron procesadas utilizando la técnica microhistológica para determinar la composición botánica estacional de la dieta de las dos especies. Se registraron 23 especies en la dieta de *L. flavigularis* y 29 para *B. taurus*. Ambos herbívoros se alimentaron principalmente de especies de Poaceae anualmente (*L. flavigularis*: temporada seca (ts) = 79.79 %, temporada húmeda (th) = 91.54 %; *B. taurus*: ts = 78.02 %, th = 84.63 %), a pesar de la significativa diferencia en la disponibilidad de especies vegetales entre temporadas. No se encontró una diferencia significativa en la composición estacional de la dieta entre ambas especies. Doce especies vegetales fueron consumidas por ambos herbívoros en las dos temporadas. La superposición alimenticia fue alta para ambas temporadas (ts O_{jk} = 0.7311, th O_{jk} = 0.8459). La amplitud del nicho trófico fue baja para ambas especies, con un traslape alimenticio alto entre éstas. Registramos un bajo uso estacional para *L. flavigularis* y *B. taurus* cuando se le compara con la disponibilidad de alimento. La baja amplitud de nicho trófico y la alta superposición alimenticia entre los dos herbívoros sugiere una competencia por recursos alimenticios en el corto plazo. Sin embargo, de acuerdo con estudios previos sobre uso de microhábitat, sugerimos que las liebres pueden beneficiarse de la presencia del ganado, siempre que la capacidad de carga no se incremente. Además, el ramoneo de *B. taurus* reduce la altura, cobertura y densidad de la vegetación, lo cual puede ayudar a *L. flavigularis* a evitar depredadores.

Keywords: Diet competition; diet overlap; grazing; México; Tehuantepec jackrabbit; livestock.

Introduction

For small and medium mammals like rodents and lagomorphs, food availability is one of the major limitations for population density (Prevedello *et al.* 2013). Studies exploring trophic interactions between leporids and other sympatric herbivores, such as livestock, are important to design conservation plans with an adequate livestock management program. It has been widely documented that, in some cases, heavy livestock grazing, and high stocking rates have an adverse impact on the density, distribution and population dynamics of leporids (Gahr 1993; Bock *et al.* 2006) and other mammals (Cortés-Marcial *et al.* 2014). Several studies have clearly shown that trophic competition occurs between leporids and other herbivores and ruminants such as cattle (Smith *et al.* 2004; Young *et al.* 2005), producing an adverse effect on leporid populations (Hulbert and Andersen 2001). However, certain leporids and livestock can coexist and obtain mutual benefits when stocking rates do not exceed the grazing capacity of their habitat (Karmiris *et al.* 2005; du Toit 2011). Furthermore, some evidence suggests that livestock grazing, whether by goats, sheep, or cattle, is beneficial to jackrabbits due to the reduction of standing biomass, which is a key factor in habitat suitability (Kuijper *et al.* 2008; Karmiris and Nastis 2010).

The Tehuantepec jackrabbit (*Lepus flavigularis*) lives in four disjunct populations within an area of 673 km^2 in the surroundings of Laguna Inferior and Laguna Superior in the Tehuantepec Isthmus, Oaxaca, México. This jackrabbit is an endangered species, endemic to Oaxaca, and is currently considered one of the most endangered leporids in the world (SEMARNAT 2010; Lorenzo *et al.* 2015, 2018; IUCN 2022). *L. flavigularis* inhabits open grasslands and xeric shrublands with the presence of isolated tree species (Carrillo-Reyes *et al.* 2012; Lorenzo *et al.* 2015). Land-use change due to the expansion of human settlements, overgrazing by cattle, and burning of pastures for seasonal agriculture, have reduced and fragmented its habitat. Existing populations are therefore almost entirely isolated and exhibit little genetic variability (Rioja *et al.* 2011; Lorenzo *et al.* 2015). A previous study described the diet of *L. flavigularis* in one locality (Montecillo Santa Cruz) and observed that it feeds mainly on grasses (66.7 % of diet). However, the diet of this species in localities that exhibit different ecological (vegetation associations) and anthropic scenario (production activities), remains unknown. At Santa María del Mar, the jackrabbit shares the grasslands with *Bos taurus* Zebu breed (treated here as synonym of *B. indicus* or *B. t. indicus*), but the trophic interaction between these herbivores is unknown. Because there is dietary overlap between cattle and other leporids like *L. californicus, Sylvilagus audubonii* (Peña-Neira 1980; Daniel *et al.* 1993), and *Oryctolagus cuniculus* (Bonino 2006, 2011), we hypothesize trophic competition between Tehuantepec jackrabbit (*L. flavigularis*) and cattle (*B. taurus*). The study aimed not only to determine the seasonal diet of an endangered leporid (*L. flavigularis*) and cattle, but also to identify possible dietary overlap between these herbivores to better understand this relationship.

Materials and methods

The study area covers an extension of 14 km^2 around the locality of Santa María del Mar (16° 14′ 7″, 16° 12′ 46″ N and - 94° 53′ 9″, - 94° 48′ 15″ W; Figure 1), in the municipality of Juchitán de Zaragoza, in the state of Oaxaca, southern México. It is located in the region of the Tehuantepec Isthmus between a coastal lake (Mar Tileme) and the Pacific Ocean. The town is inhabited by over 800 people whose main productive activities are fishing and cattle production, and occasionally, seasonal agriculture and subsistence hunting (Carrillo-Reyes *et al.* 2010). The local climate is warm sub-humid with a pronounced dry season, summer rains, and average annual precipitation of 800 mm ($\mathrm{Aw}_{0,}$ savanna like). The driest month has less than 60 mm of precipitation and the average annual temperature is 30 °C. The wet season occurs between May and October with a short dry period in August, while the long dry season begins in November and ends in April (García and Comisión Nacional para el Conocimiento y Uso de la Biodiversidad 1998; Rioja-Paradela *et al.* 2012).

This *L. flavigularis* population is the most abundant of the four existing; Vargas (2000) recorded 12 individuals/km^2 (0.12 individuals/ha) although this value has decreased to 8 individuals/km^2 (0.08 individuals/ha; Chacón-Trinidad *et al.* 2020). The habitat of *L. flavigularis* is characterized by extensive zones of grassland, dominated by *Eragrostis prolifera*, *Jouvea pilosa* and *Whalteria preslii* (Carrillo-Reyes *et al.* 2012). Also, isolated individuals of *Opuntia tehuantepecana* and *O. decumbens* are present; these areas are grazed by cattle (Carrillo-Reyes *et al.* 2010). *B. taurus* and *L. flavigularis* are the only large and medium herbivores present in this grassland. In the scrubland surrounding the pasture occurs the Eastern cottontail (*Sylvilagus floridanus*) but does not make use of the grassland; its habitat is limited to the bush, so it does not compete for food or territory with the jackrabbit or the livestock (Rioja-Paradela 2008). A recent study showed that in the grassland association the density of cattle was eight individuals/ha (800 individuals/km^2; Chacón-Trinidad

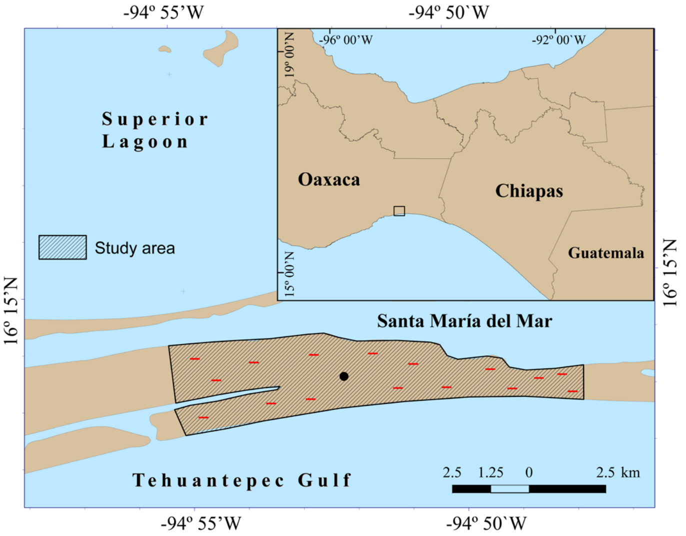

Figure 1. Study area, with vegetation transects shown in red lines.

et al. 2020), and those cattle grazed in paddocks from 8:00 to 20:00 hrs. There is no rotational grazing; cattle management depends on the availability of "paddocks to lease" and the ability of livestock owners to rent these paddocks.

We made two visits to the study area, one for dry and one for wet season, each lasting 15 days. For vegetation sampling in both seasons, 16 linear transects of 60 m were randomly established with a distance of at least 100 m between them (Carrillo-Reyes *et al.* 2010). Forage availability was estimated considering vegetation cover as an approximate measure of availability that is compatible with fecal samples at a spatial–temporal scale (Norbury and Sanson 1992; Kufner *et al.* 2008; Tirado *et al.* 2012). To record the cover of grasses and herbaceous species along each transect, five circular plots of 1 m^2 were established at 10-m intervals along each linear transect, for a total of 80 circular plots. To estimate the shrub cover, one circular plot of 12.6 m^2 was established at the center of each linear transect, for a total of 16 circular plots. Calculation of absolute coverage was based on the methodology described by Río-Olague (1999), and relative vegetation cover was calculated using the formula of Franco-López *et al.* (1989). Significant differences ($P < 0.05$) in the forage availability between dry and wet season were determined by U Mann-Whitney test (Bauer 1972). For all plant species, samples of leaves and fruits were collected and later processed by the microhistological technique to create a reference collection. This collection was later used to identify the species in the diet of the two herbivores.

During each visit to the study area, we collected *L. flavigularis* and *B. taurus* fecal samples. For each species, the freshest excreta were collected along the same transects used for vegetation (16 sampling sites, 1 per vegetation transect), to increase the probability of collecting samples from different individuals. At each transect, random *L. flavigularis* pellets and *B. taurus* dung pats were collected and placed in paper bags for transport at ambient temperature. From all fecal samples collected, a total of 20 *L. flavigularis* random pellets were chosen. Also, for *B. taurus* the sample was homogenized (the sample was dispersed and mixed homogeneously), and then a random sample of approximately 10 g of excreta was chosen. The samples were then dried at 75 °C for 24 h before subsequent analysis (Bonino 2006; Lorenzo *et al.* 2011).

The seasonal and annual botanical composition of the diet was determined by microhistological analysis of plant epidermal fragments present in the feces (Peña-Neira and Habib-de Peña 1980; Kufner *et al.* 2008; Lorenzo *et al.* 2011). This technique was used because it does not imply disturbing wildlife and no extractions are needed, which is particularly important for a critically endangered species. For each transect and every species, five temporary slides were prepared, for a total of 80 slides per species. To prepare fecal samples for analysis, the material was cleared using a commercial solution of sodium hypochlorite; samples were immersed approximately five minutes in this solution and washed in water for 20 minutes (Kufner *et al.* 2008). A plastic template with 7 mm diameter and 5 mm thick holes was used to mount the samples. The template was placed on the slides (so that each slide had the same amount of sample), and the holes were filled with the wet material after being washed. A commercial formula of corn syrup was used as mounting medium for temporary slides. After preparation, slides were sealed using transparent glaze and stored to dry for five days. Microphotographs were taken of all slides. On each slide, 20 fields were examined with an optical microscope (objective x40); five separate slides were examined for each sample, with a total of 100 fields per sampling site and a total of 1,600 per species. Slides were examined using randomly generated non-overlapping coordinates. Microscopic identification of species was performed by comparison with the reference collection of microscope slides of plants. Items whose tissue showed at least three diagnostic microhistological elements were identified to species level. Items that did not meet this criterion were not considered. Unidentified fragments were recorded as unidentified monocotyledons or dicotyledons. We recorded the plant species and accumulated frequency (number of fields in which each identified species was recorded). Botanical composition was obtained by transforming frequency to density using the Fracker and Brischle (1944) table (Lorenzo *et al.* 2011).

Species richness for each season was determined by the number of registered species (Lorenzo *et al.* 2011). Differences ($P < 0.05$) in the diet of both species between the dry and wet seasons were determined by U Mann-Whitney test (Bertolino *et al.* 2009; Desbiez *et al.* 2009) and corroborated with a Sorensen quantitative test (*QS*; Morgia and Bassano 2009). The comparison was made by contrasting the density of each plant species in the diet. Niche breadth was assessed using Levins' measure, $B_j = 1/\Sigma\ p_{ij}^2$, where p_{ij} is the proportion of diet contributed by plant species *i* on a given mammal species (Levins 1968). This was standardized to a scale of 0 - 1 following $B_j = (B - 1)/(N - 1)$ where *N* is the total number of plant species. The total number of species eaten at least once by at least one herbivore in each season was used to calculate the index (Mishra *et al.* 2004; Bertolino *et al.* 2009).

Interspecific trophic relationship was analyzed based on seasonal diet composition. Diet similarity was evaluated with U Mann-Whitney test (Bertolino *et al.* 2009) and corroborated with a Sorensen test (Morgia and Bassano 2009), contrasting the density of each plant species. Dietary overlap was estimated with the Pianka (1975) index, performing 5,000 Monte Carlo randomizations to determine the difference between the simulated data and the result of overlap (Desbiez *et al.* 2009).

To determine the relationship between the seasonal diet of each species and the forage availability in the same season the Pianka (1975) index (Kufner *et al.* 2008) was used. We use vegetation cover as an indicator of forage availability (Kufner *et al.* 2008). This analysis can indicate the degree of resource selection at a specific time and can corroborate the role of the species as generalist or specialist. All analyses were performed with the software R and RStudio (R Core Team 2020; RStudio Team 2020) and packages "EcoSimR" (Gotelli *et al.* 2015), "spaa" (Zhang 2013) and "fossil" (Vavrek 2011).

Results

During the dry season, 33 species of non-woody plants (16 grasses and 17 forbs, *i. e.*, non-grass herbaceous plants) and 16 species of woody plants were recorded. In the wet season, 68 species of non-woody plants (18 grasses and 50 forbs) and 22 species of woody plants were recorded. We found a highly significant difference in forage availability between the dry season and the wet season (U Mann-Whitney test, *W* = 357, *P* = 0.001; Figure 2).

Twenty-tree plant species were recorded in the diet of *L. flavigularis* and 29 species were in the diet of *B. taurus* (Table 1). Both herbivores fed primarily on Poaceae species throughout the year (*L. flavigularis*, dry = 79.79 %, wet = 91.54 %; *B. taurus*, dry = 78.02 %, wet = 84.63 %, Figure 3). Less consumed species were forbs (*L. flavigularis*, dry = 20.21 %, wet = 8.46 %; *B. taurus*, dry = 14.09 %, wet = 13.90 %) and shrubs (*L. flavigularis*, dry = 0.00 %, wet= 0.00 %; *B. taurus*, dry = 1.32 %, wet = 0.83 %).

The most important items in the diet of *L. flavigularis* were grasses and forbs, *Bouteloua repens* (27 %), *Stipa emi-*

Table 1. Botanical composition (%) of the diet of *L. flavigularis* and *B. taurus* by season. The percentages are presented in parentheses.

Family	Species	Life form	*L. flavigularis*		*B. taurus*	
			Dry	Wet	Dry	Wet
Amaranthaceae (7.69 %)	*Amaranthus scariosus*	Forb	0.56	0.00	0.00	0.00
	Gomphrena globosa	Forb	0.00	4.04	0.00	0.00
	Gomphrena decumbens	Forb	0.00	0.00	0.00	0.44
Asteraceae (5.12 %)	*Erigeron oaxacanus*	Forb	6.62	2.01	1.85	2.63
	Lactuca intybacea	Forb	0.79	1.34	0.12	2.28
Cactaceae (2.56 %)	*Opuntia tehuantepecana*	Shrub	0.00	0.00	0.49	0.00
Commelinaceae (2.56 %)	*Commelina erecta*	Forb	7.13	0.00	0.00	0.00
Convolvulaceae (2.56 %)	*Ipomoea minutiflora*	Forb	0.00	0.00	0.59	0.77
Cyperaceae (2.56 %)	*Cyperus articulatus*	Forb	4.79	0.14	0.16	0.07
Euphorbiaceae (5.12 %)	*Chamaesyce lasiocarpa*	Forb	0.00	0.00	0.40	0.12
	Dalechampia scandens	Forb	0.00	0.00	2.39	0.00
Fabaceae (15.38 %)	*Acacia* sp.	Shrub	0.00	0.00	4.79	0.00
	Centrosema pascuorum	Forb	0.00	0.00	0.00	3.56
	Chamaecrista hispidula	Forb	0.00	0.00	0.00	0.28
	Desmodium barbatum	Forb	0.00	0.57	0.00	0.00
	Desmanthus virgatus	Shrub	0.00	0.00	2.61	1.48
	Galactia argentea	Forb	0.08	0.35	0.00	0.00
Gentianaceae (5.12 %)	*Eustoma exaltatum*	Forb	0.23	0.00	0.00	0.00
Malvaceae (5.12 %)	*Melochia pyramidata*	Forb	0.00	0.00	1.95	0.55
	.	Forb	0.00	0.00	4.32	0.00
Poaceae (41.02 %)	*Sorghum halepense*	Grass	0.00	10.64	0.00	0.00
	Bouteloua aristidoides	Grass	10.11	11.38	1.81	8.42
	Bouteloua hirsuta	Grass	0.00	0.00	0.00	0.04
	Bouteloua repens	Grass	27.00	18.55	22.13	22.94
	Bouteloua sp.	Grass	0.00	0.00	0.26	0.00
	Cenchrus echinatus	Grass	2.45	4.47	1.29	4.63
	Digitaria ciliaris	Grass	10.28	6.72	8.31	5.77
	Digitaria filiformis	Grass	0.29	1.37	2.43	2.66
	Eragrostis glomerata	Grass	0.48	0.00	0.00	0.00
	Eragrostis prolifera	Grass	2.24	5.01	20.47	10.18
	Grass - Unidentified sp1	Grass	3.07	0.97	0.31	2.19
	Hilaria belangeri	Grass	1.63	1.06	1.62	2.85
	Jouvea pilosa	Grass	0.54	0.80	4.48	1.87
	Muhlenbergia sp.	Grass	2.47	0.00	0.00	0.00
	Paspalum prostatum	Grass	0.00	0.00	0.00	3.68
	Stipa eminens	Grass	16.87	29.32	14.88	19.43
	Stipa sp.	Grass	2.37	1.24	0.00	0.00
Solanaceae (5.12 %)	*Hydrolea spinosa*	Forb	0.00	0.00	2.11	3.17
Verbenaceae (5.12 %)	*Phyla nodiflora*	Forb	0.00	0.00	0.19	0.02

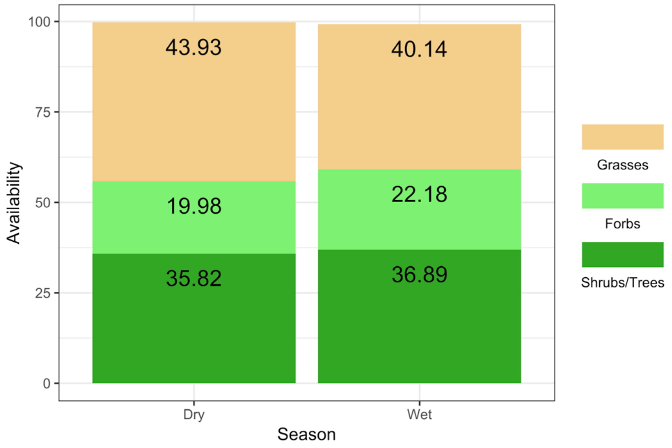

Figure 2. Availability (%) of plant species by growth form and by season in Santa María del Mar, Oaxaca, México.

nens (16.87 %) and *Digitaria ciliaris* (10.28 %), during the dry season, and *S. eminens* (29.32 %), *B. repens* (18.55 %) and *B. aristidoides* (11.38 %) during the wet season. For *B. taurus*, the most important items were grasses and forbs, *B. repens* (22.13 %), *Eragrostis prolifera* (20.43 %) and *S. eminens* (14.88 %) during the dry season, and *B. repens* (22.94 %), *S. eminens* (19.43 %) and *E. prolifera* (10.18 %) during the wet season.

No significant differences were found in the seasonal composition of the diet of *L. flavigularis* ($W = 911.5$, $P = 0.78$) or *B. taurus* ($W = 893.5$, $P = 0.91$). These results were corroborated by the Sorensen quantitative test, which showed a high similarity between the seasonal diet of *L. flavigularis* ($QS = 0.8540$) and that of *B. taurus* ($QS = 0.8957$). The trophic niche breadth was low for both species (*L. flavigularis*, dry = 0.1439, wet = 0.1250; *B. taurus*, dry = 0.1663, wet = 0.1674).

From 39 species, 12 were consumed by both species during the two seasons. Seasonally, *L. flavigularis* and *B. taurus* shared 13 species on both dry and wet seasons (Table 1). This was coincident with dietary overlap analysis; according to the Pianka (1975) index, the dietary overlap between the two species was high for both seasons (dry $O_{jk} = 0.7311$, wet $O_{jk} = 0.8459$). We recorded low seasonal use of available plant species for *L. flavigularis* (dry season $O_{jk} = 0.1788$; wet season $O_{jk} = 0.3102$) and for *B. taurus* (dry $O_{jk} = 0.3378$; wet $O_{jk} = 0.4022$).

Discussion

Results indicate that *L. flavigularis* and *B. taurus* exploited a relatively narrow variety of available species of plants, suggesting that both herbivores are selective, showing a preference for Poaceae species throughout the year despite the significant difference in the availability of plant species between the dry and wet season. The Poaceae preference of *L. flavigularis* is consistent with the findings of Lorenzo *et al.* (2011) in another isolated *L. flavigularis* population and with other leporid diet studies (López-Cortés *et al.* 2007; Karmiris and Nastis 2010; Kontsiotis *et al.* 2011; Ge *et al.* 2013; Freschi *et al.* 2014, 2015; Luna-Casanova *et al.* 2016). However, we found that some species of plants consumed by *L. flavigularis* in Santa Maria represent new records for this leporid. The Poaceae preference of *B. taurus* is also consistent with previous studies in other localities (Quinteros *et al.* 2013).

These results are also related to the plant species availability. The study area is located in a low precipitation region from the Tehuantepec Isthmus, with severe drought from November to April. Despite the fact that grasses have low protein content in comparison to other species (Codron *et al.* 2007), and contain abrasive silica (Sanson *et al.* 2007), these species are more resistant to drought than ephemeral or annual forbs (Tilman and Downing 1994) which may cause that grass availability is high year-round. Also, Poaceae species distribute in open areas (Gordon and Prins 2008), which is one of the main characteristics of grassland habitat in the Tehuantepec Isthmus (Farías and Fuller 2009; Rioja *et al.* 2011). In agreement with these findings, it has been reported that *L. flavigularis* prefer grassland over other available habitats because, besides providing food, it represents a suitable place to carry out its activities of resting, socialization and reproduction (Farías and Fuller 2009; Rioja *et al.* 2011; Carrillo-Reyes *et al.* 2012; Lorenzo *et al.* 2015; Luna-Casanova *et al.* 2016).

Studies show the clear occurrence of trophic competition between leporids and other herbivores and ruminants such as cattle (Smith *et al.* 2004, Young *et al.* 2005), producing an adverse effect on leporid populations (Hulbert and Andersen 2001). In our study, *Lepus flavigularis* and *B. taurus* had a low trophic niche breadth and high dietary overlap, which indicates a high level of resource (trophic) competition that could adversely affect the *L. flavigularis* population. Other studies state that *L. flavigularis* prefers to establish feeding, resting, and breeding sites in pastures with the presence of *B. taurus* (Carrillo-Reyes *et al.* 2010, 2012; Rioja *et al.* 2011; Luna-Casanova *et al.* 2016). It is likely that the presence of *B. taurus* influence the existence of certain plant species that could serve as a forage resource for *L. flavigularis*, through the establishment of seedlings from *B. taurus* feces (Kuijper *et al.* 2008). Furthermore, *B. taurus* grazing reduce height, cover, and density of vegetation (Smith *et al.* 2005; Karmiris

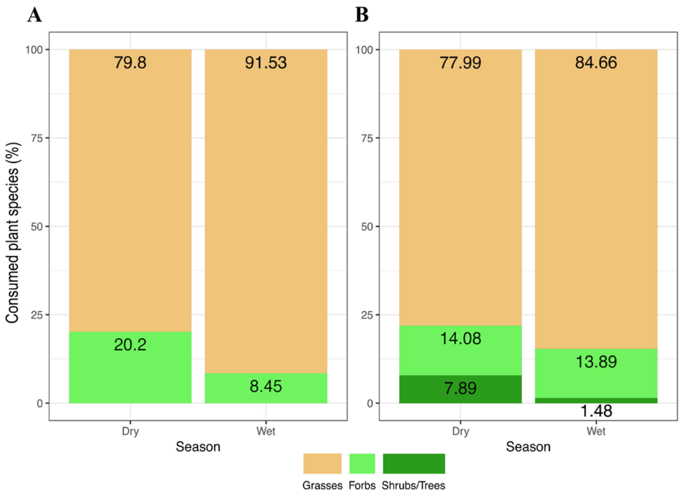

Figure 3. Percentage of consumed plant species (%) by growth form and by season in Santa María del Mar, Oaxaca, México. A: *L. flavigularis*, B: Cattle.

and Nastis 2010; Rioja *et al.* 2011). As Farías and Fuller (2009) stated, open grasslands with scattered trees and shrubs can help *L. flavigularis* to avoid predators like *Canis latrans*. Therefore, selection of areas with low vegetation cover may reduce the energy spent in monitoring its habitat, which favors the investment of more time in foraging (Karmiris and Nastis 2010; Rioja *et al.* 2011; Luna-Casanova *et al.* 2016). According to previous literature, we expect that jackrabbits benefit from cattle presence, as long as the stocking rate does not increase current levels. Research suggests that dietary partition between grazing herbivores is a common phenomenon and that leporids and cattle can coexist and obtain mutual benefits while not exceeding grazing capacity (Karmiris *et al.* 2005; Karmiris and Nastis 2010). Over long periods, livestock can even improve forage quality and foraging efficiency, facilitating food availability for leporids (Kuijper *et al.* 2008; du Toit 2011).

Low trophic niche breadth and high dietary overlap between *L. flavigularis* and *B. taurus*, combined with a low seasonal relationship between food availability and diet, suggest that forage resources competition is occurring in this system. Exotic species such as *S. eminens* and *D. ciliaris*, and a native species such as *B. repens*, were highly consumed by both species throughout the year. It is likely that these plant species remain permanently available to both herbivores, either as fresh or dry forage, due to its high silica content and their ability to survive in areas with low water content. On the other hand, certain species were consumed in a certain season by some species. For example, *C. articulatus* and *C. erecta* were consumed by *L. flavigularis* mainly during the dry season, while species *S. halepense* was consumed during the wet season. We believe that the mobility capacity of the species partly determined these differences. Cattle are restricted to using the resources available in the pastures and roads in which they are kept, while the hare can use almost the entire available area. Hence, it also has permanent or temporal access to all available plant species.

In conclusion, our results show trophic competition between native and no-native herbivorous species. However, we suggest that both species can coexist as long as the site's carrying capacity is not exceeded. On the one hand, although both species feed mainly on grasses, these plant species are the ones that persist throughout the year, even in drought conditions. Additionally, cattle have limited movement to pastures, while *L. flavigularis* can move freely throughout its range. Also, cattle grazing reduces vegetation's height, cover, and density, facilitating *L. flavigularis* to avoid potential predators. Overall, cattle management at moderate stocking densities, can be compatible with the subsistence of *L. flavigularis* populations.

Acknowledgements

This work was supported by México's Consejo Nacional de Ciencia y Tecnología (project No.166702). We thank the municipal and communal authorities of Santa María del Mar, Juchitán, Oaxaca, and especially all local families. We also thank the anonymous reviewers for their comments and suggestions that greatly improved this manuscript.

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Associated editor: Rafael Avila Flores
Submitted: December 27, 2020; Reviewed: February 16, 2021
Accepted: August 30, 2022; Published on line: September 9, 2022