DOI:10.12933/therya-25-6202 ISSN 2007-3364

Seasonal Composition of the Diet of Free-Range Equines in Northern Coahuila, Mexico

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Donkeys and horses are large non-ruminant herbivores distributed throughout the world. They are part of the cultural heritage of many countries and consume natural resources when they graze freely. In Mexico, the potential or current impacts of these animals on natural habitats shared with wildlife and other domestic animals have been scarcely documented. The objectives of this study were to evaluate the ecological variables diversity, richness, and diet similarity, and to identify the most commonly consumed plant species in spring and summer. The study was conducted in northern Coahuila. The dietary content of equine fecal samples was analyzed using microhistology. A total of 43 plant species were identified in the diet, with biodiversity values ranging from 2.12 to 2.34. Plant composition varied between seasons, showing less than 60% similarity. The most frequent species included *Opuntia macrocentra*, grasses such as *Cynodon dactylon*, *Erioneuron pulchellum*, *Bouteloua gracilis*, and *B. curtipendula*, and *Aloysia wrightii* among the herbaceous plants. Grasses made up most of the diet in spring, while herbaceous plants were dominant in summer. This information serves as a reference for grazing management in northern Coahuila, where cattle farming is becoming increasingly challenging. Diversifying land use and balancing it with the habitat needs of wildlife should be considered.

Keywords: donkeys, feeding preferences, horses, microhistology.

Los burros y caballos son grandes herbívoros no rumiantes presentes en todo el mundo formando parte de la cultura de muchos países y que también hacen uso de los recursos naturales cuando están en libre pastoreo. En México se han documentado escasamente los impactos potenciales o reales que estos animales causan en los hábitats naturales que comparten con fauna silvestre y otros animales domésticos. El objetivo fue evaluar las variables ecológicas de diversidad, riqueza y similitud de la dieta, e identificar las especies de plantas más consumidas en primavera y verano. El estudio se llevó a cabo en el norte de Coahuila. Se analizó el contenido de la dieta en excretas de equinos usando microhistología. La riqueza de plantas que componen la dieta fue de 43 especies, el valor de biodiversidad fluctuó entre 2.12 y 2.34 y la composición botánica no fue muy similar (<60%) entre estaciones. Se identificaron especies con mayor ocurrencia, como *Opuntia macrocentra*, especies de gramíneas como *Cynodon dactylon, Erioneuron pulchellum, Bouteloua gracilis* y *B. curtipendula*, además de *A. wrightii* en el grupo de herbáceas. En primavera las gramíneas constituyen la mayor parte de la dieta, mientras que en verano lo fueron las herbáceas. Esta información marca una referencia a considerar para el manejo de agostaderos en el norte de Coahuila, donde la cría de ganado bovino es cada vez más un reto, su diversificación y el balance con las necesidades de hábitat de la fauna silvestre deben ser consideradas.

Palabras clave: burros, caballos, microhistología, preferencias alimenticias.

Equines were first introduced to North America by the Spaniards round 1530 (Lugo and Alatriste-Contreras 2020). Donkeys were used as one of the main labor forces and expanded into the United States during the gold rush, when their use in mining activities increased due to their hardiness (Seegmiller and Ohmart 1981; Wolfe 1983). For their part, horses have played a key role in various cultures, as a component of war strategies and facilitating new communication modalities. In Mexico, horses have gained a prominent place within the national culture, especially in the context of the sport known as *Charrería* (Palomar 2004; Robledo-Reyes *et al.* 2024).

The original habitat of donkeys is predominantly desert (Seegmiller and Ohmart 1981; Wang *et al.* 2022), while horses evolved in open areas dominated by grasses and herbaceous plants, with little visual obstruction (Mihlbachler *et al.* 2011; Secord *et al.* 2012). Despite their cultural and economic importance, there is limited information available on equine populations in Mexico. In 2007, approximately 72 800 equine heads (horses, mules, and donkeys) were reported in the state of Coahuila, particularly in the municipalities of Cuatro Ciénegas, Saltillo, and Ocampo (INEGI 2013). The National Agricultural Survey (Encuesta Nacional Agropecuaria; INEGI 2020) estimated the existence of 1.5 million horses, mares, and their offspring, as well as approximately one million donkeys in the country. However, there is no specific inventory of equines for Coahuila, nor is there updated data on free-range equines. This situation is even more critical for feral populations, mainly donkeys, which live with little or no human contact in the strip bordering Coahuila and the United States of America (Stangl *et al.* 2007). These animals exhibit behaviors similar to those of native wildlife, which pose additional challenges in understanding their food ecology and impact on native vegetation.

In northern Coahuila, rural communities depend on economic activities such as the extraction of *candelilla* wax from *Euphorbia antisyphilitica* Zucc. and extensive livestock farming. In this context, donkeys play a central role as pack animals, facilitating access to remote mountainous areas during *candelilla* harvest (Ochoa *et al.* 2017; Jurado-Guerra *et al.* 2021). Similarly, cow-calf production is the main cattle-farming activity in the region, supplemented by breeding goats for cabrito and horses for labor (De los Reyes 2018). Historically, extensive livestock farming in Mexico has primarily focused on cattle, goats, and sheep, which has influenced land-use planning and carrying-capacity estimates, leaving horses in the background (Beck *et al.* 2020; Wells *et al.* 2022). Although equines have market value, they are rarely integrated into livestock calculations, unless the productive entities are dedicated solely to equine breeding (Fleurance *et al.* 2016).

There is scarce knowledge about the diet of equines and the plant resources consumed by them under wild or semi-wild conditions. Equines are known to consume a wide range of plant species, including grasses, herbs, and shrubs (Scasta *et al.* 2016; Gordon and Prins 2023). However, most studies have been conducted in temperate or arid regions of the United States and Europe, with a particular focus on grassland management, competition with other domestic species, or habitat conservation (Menard *et al.* 2002; Launchbaugh and Howery 2005; Harris *et al.* 2017). This geographic bias limits the understanding of equine food ecology in tropical, subtropical, or non-pastoral landscapes, where their interaction with vegetation could be significantly different (Harris *et al.* 2017). At the country level, studies on equine diet are virtually non-existent, which limits our understanding of their ecological role, especially in semiarid regions of northern Mexico where their presence is prevalent but scarcely documented.

Several studies have investigated the diet composition of free-range equines in various regions of the world using direct observation, microhistological analysis, DNA barcode identification in fecal samples, and near-infrared spectroscopy (NIRS) (Duncan 2012; Kartzinel *et al.* 2015; Harris *et al.* 2017; Castellaro *et al.* 2021). Horses exhibit a preference for grasses and pastures, although they can adjust their diet according to seasonal food availability (Scasta *et al.* 2016; Castellaro *et al.* 2021). Likewise, a review of the diet of wild donkeys in arid areas indicates that this species consumes around 175 plant species, with a marked preference for grasses and herbaceous plants (Abella 2008). Menard *et al.* (2002) suggest that although feral equines can exploit niches supplementary to those of domestic ruminants and, therefore, coexist with them under certain management conditions, this coexistence largely depends on the season of the year, since the trophic overlap between both groups may increase in certain periods. This background information suggests that the diet of equines varies not only according to the type of ecosystem but also in response to seasonal, physiological, and social factors, underscoring the need for regional studies that consider these variables.

The lack of regional studies on equine food ecology hinders the design of sustainable management strategies. The seasonal variability of their diet, the selection of plant species, and the potential impact on vegetation structure have not yet been systematically evaluated. Therefore, the objectives of this study were to: (1) evaluate the richness, diversity, and similarity of the equine diet during the wet and dry seasons; (2) describe the composition of the diet and identify the plant species that are consumed most frequently. This information will expand our knowledge about the ecological role of equines in semiarid ecosystems, enabling the implementation of sustainable management strategies that benefit both the conservation of natural resources and the optimization of equine livestock in natural grasslands of northern Mexico. These findings will set the foundation for future adaptive management strategies in landscapes where traditional human activities coexist with populations of domesticated or feral equines.

Materials and methods

Study area. - The study was conducted in the north of the Ocampo municipality, state of Coahuila, where rosetophyllous and microphyllous desert shrublands predominate. The most representative shrub species include the creosote bush (*Larrea tridentata* (DC.) Coville), Joshua tree (*Yucca* spp.), mesquite (*Neltuma glandulosa* Torr.), and prickly pear cactus (*Opuntia macrocentra* Engelm.). The most common native grasses belong to the genera *Bouteloua* spp. and *Aristida* spp., while the dominant species in the herbaceous stratum belong to the families Asteraceae, Fabaceae, and Brassicaceae (Powell 1998; Ochoa *et al.* 2017). The predominant soil type is Calcaric Regosol, mainly in lowlands or flat areas (INEGI 2021).

According to the climate classification of Peel *et al.* (2007), the region has an arid hot-desert climate with cool winters (BWh). The nearest meteorological station is San Miguel (National Meteorological Service code 5013), with records dating back to 1960. The mean annual precipitation is 244.2 mm, with 2010 being the rainiest of the past 15 years, with 592 mm; July is the month with the highest mean precipitation, while March is the driest month. The mean annual temperature is 20.9 °C, with maximum and minimum records of 41.1 °C and -4 °C, respectively. The study area is characterized by rugged relief with prominent mountain ranges such as *El Terminal*, *San Vicente*, *Carrasco*, and *La Harina*. The maximum altitude is 1700 m a.s.l. in the Sierra de San Vicente, while the minimum altitude is 550 m on

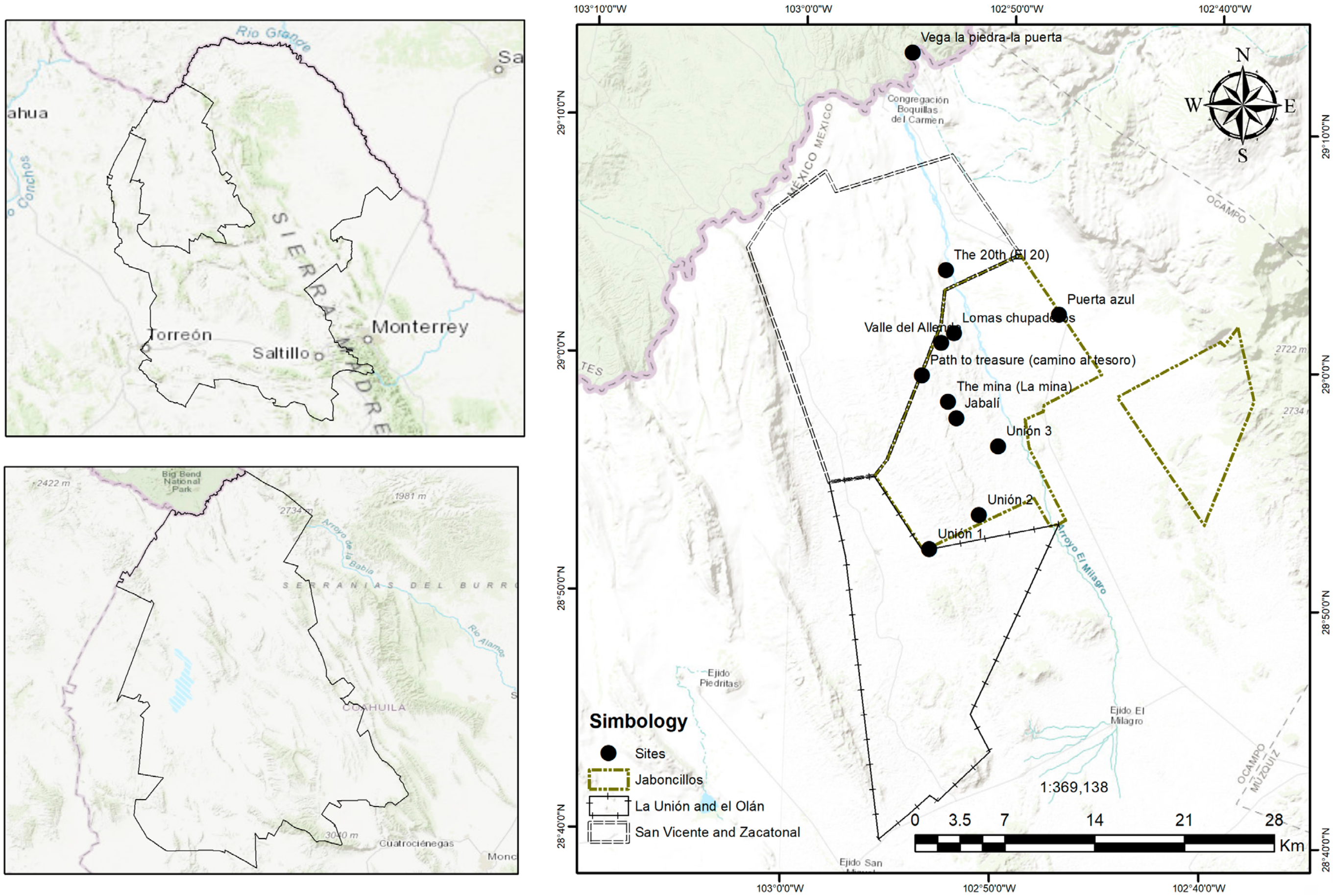

Figure 1. Study area and equine excreta collection sites in the ejidos *San Vicente y Zacatonal*, *Jaboncillos Grande*, and *La Unión y El Olán*, north of the Ocampo municipality, state of Coahuila, Mexico.

the bank of the Rio Grande. This study covered three ejidos, Jaboncillos Grande, La Unión y El Olán, and San Vicente y Zacatonal, all in the municipality of Ocampo, Coahuila (Figure 1). The study area extends over 68,000 hectares in which cattle move freely, since the ejidos are not bordered by metal fences that may restrict their movement. Land use in the region is dominated by extensive livestock farming, mainly cattle and goats, under a continuous grazing regime.

Fieldwork. – During April (referred to as spring) and July (referred to as summer) 2012, we traveled the dirt road network in the study area, collecting feces samples randomly in areas where the local inhabitants reported the presence of feral or free-range equines. At each sampling site, the presence and use of the area by equines was verified by observing signs such as resting areas, browsing traces, paths, tracks, or physical presence of animals. Between three and five fecal samples were collected per site, within a radius of 10 to 20 meters from the point where the most recent feces (excreta) were found. Excreta were considered fresh if they were soft, without signs of degradation by insects, and not completely dry after prolonged sun exposure. The fecal samples were stored in paper bags and labeled with the date, coordinates, and site code.

In total, 18 fecal samples were collected from five sites during spring and 20 samples from six sites during summer (Figure 1). The sample size was defined based on the number of excreta collected in spring; then, the same number of samples was collected in summer, following a non-probabilistic sampling principle (Makwana *et al.* 2023). Given the broad extension of the study area and the unique occupation of equines (Bakaloudis *et al.* 2024), the number of sampling sites adequately represents the use of space by these animals. In the sampling area, no horses were observed in the wild, and occupation mainly involved feral donkeys. However, since horse, donkey, and mule excreta are morphologically indistinguishable in the field, all collected samples are referred to herein as equine excreta.

Laboratory testing. – We employed the microhistological identification technique described by Holecheck *et al.* (1982), which is based on the comparison of plant cells in excreta with those of potentially consumed plant species. To this end, at each site, we collected samples from the edible parts of plants potentially consumed, as well as those that showed evidence of consumption, to create a reference catalog.

Sample processing began with a sun-drying phase followed by oven-drying at 75 °C for at least 48 hours to prevent fungus growth. Subsequently, the excreta and plant samples were ground, sieved to a particle size of no larger than 1.70 mm, and mounted on slides. For identification of cell structures, images were captured using a camera coupled to a stereo microscope using 20x

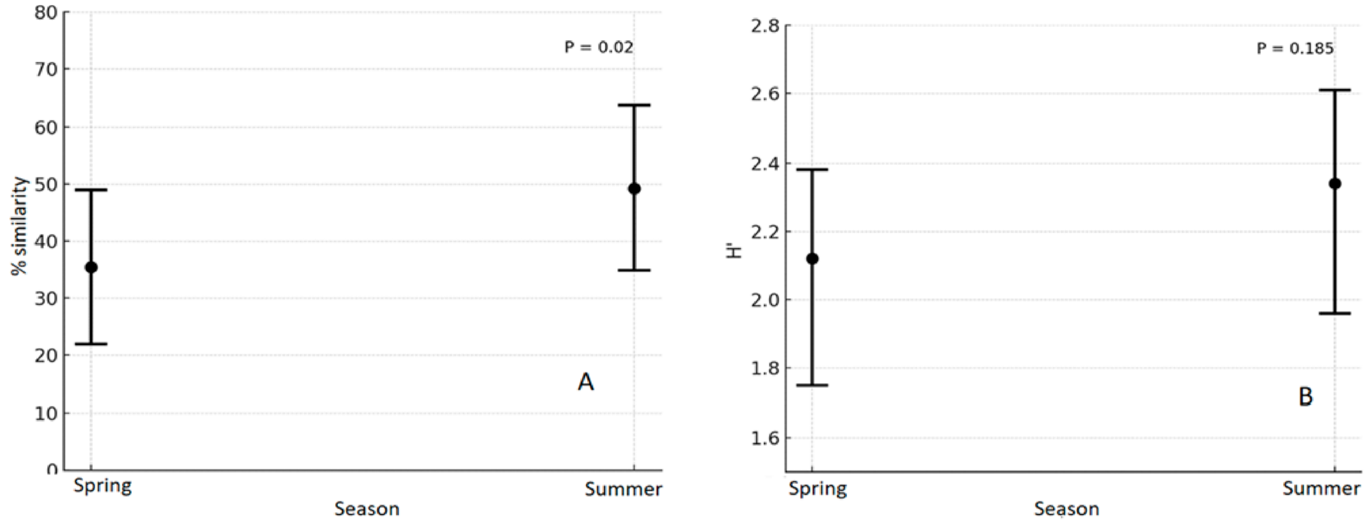

Figure 2. Bray-Curtis similarity index (A), mean and standard deviation; and Shannon-Wiener diversity index (B), with 95 % CI, of the diet of free-range equines during spring and summer in northern Coahuila.

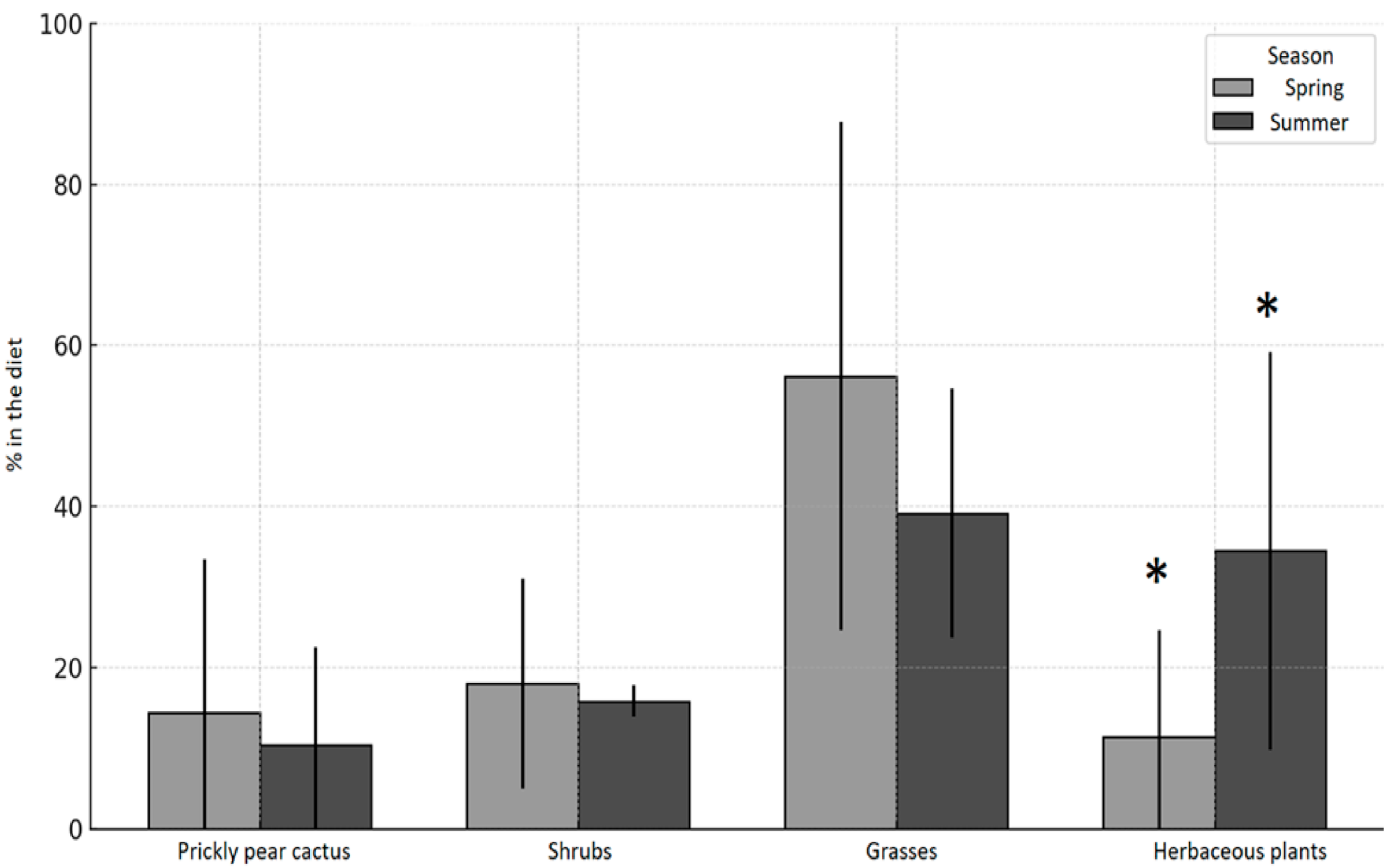

Figure 3. Composition of the diet of free-range horses by biological form, highlighting the participation of prickly pear cactus (*Opuntia macrocentra*), during spring and summer in northern Coahuila. Different letters indicate a significant difference ($P < 0.05$).

and 40x magnifications. These images were integrated into the reference catalog used in the microhistological identification process.

Microscopic analysis. - For each study site, a composite sample was prepared by thoroughly mixing the collected feces to ensure a homogeneous mixture. Five slides of each composite sample were mounted, each with 20 observation fields, for a total of 100 objective fields per site. Overall, 600 fields were examined for spring and 500 for summer. Each sample was examined under the microscope to determine the seasonal plant composition of the diet based on the relative frequency of cell traces of each identified species (Fracker and Brischle 1944; Holecheck *et al.* 1982; Garnick *et al.* 2018).

A database was created that included the identification of the species consumed in each season and their classification within functional groups: grasses, herbaceous plants, and shrub species. However, given the high percentage of prickly pear cactus (*O. macrocentra*) fibers in the diet, this species was analyzed separately to evaluate possible food preferences, keeping it within the shrub species group for functional classification purposes.

Data analysis. – The Shannon-Wiener index (H'), species richness (S), and Bray-Curtis similarity index were calculated; the latter was selected for its ability to integrate data on the relative abundance of species, its ease of interpretation, and its applicability in quantitative ecology studies (Ricotta and Podani 2017). The analyses were performed using the PAST program, version 3.19 (Hammer 2024). Seasonal differences in dietary diversity were evaluated using the Student's t-test ($\alpha \leq 0.05$). To identify similarity patterns between dietary components, a cluster analysis was applied using the averaging method (Ter Braak, 1987). Dissimilarity was measured using the Euclidean distance, which quantifies the proximity between cases in a multidimensional space. Finally, the reliability of the hierarchies projected in the dendrogram generated in PAST was determined by calculating the cophenetic correlation coefficient, which measures the degree of agreement between the original distances and the distances in the dendrogram.

Results

Ecological variables. - Regarding species richness, we identified a total of 43 plant species in the diet of equines in the study area, 36 in spring (83.7 % of the total) and 37 in summer (86.0 %), with 30 species common to both seasons. The mean number of taxa per site was slightly higher in spring (20.33 ± 4.17) than in summer (19.80 ± 2.38), with no significant difference between seasons ($P > 0.05$).

Only one cell structure did not match the species recorded in the reference catalog; therefore, it was classified as an "unidentified plant". For the functional group of shrubs, the following species were detected at trace levels in spring: *Atriplex canescens* (Pursh) Nutt., *Ephedra antisyphilitica* Berland., *Karwinskia humboldtiana* (Schult.) Zucc. and *Berberis trifolilata* Moric. In the case of grasses, *Muhlenbergia porteri* Scribn. accounted for less than 1 % of the diet.

During summer, also at the trace level, five shrub and herbaceous species were identified: *Buddleja marrubiifolia* Benth., *Celtis pallida* Torr., *Viguiera stenoloba* S.F. Blake, *Dyssodia setifolia* (Lag.), and *Senecio flaccidus* (Less.).

The dietary diversity, assessed by the Shannon-Wiener index, was higher in summer compared to spring (2.34 vs. 2.12, respectively), although the difference was not statistically significant ($P > 0.05$) (Figure 2). On the other hand, the similarity in the composition of the diet, based

Table 1. Percentage composition of the diet of free-range horses by plant species and biological form in two seasons (spring and summer) in northern Coahuila.

Species	Spring	Summer	Species	Spring	Summer
Shrubs (%)					
Acacia farnesiana	0.51	3.06	*Krameria erecta*	1.16	0.81
Acacia rigidula	2.08	5.49	*Larrea tridentata*	2.27	1.70
Atriplex canescens	0.18		*Leucophyllum frutescens*	5.26	0.79
Buddleja marrubifolia		0.63	*Berberis trifoliolata*	0.18	
Celtis pallida		0.22	*Parthenium incanum*	2.40	2.12
Dalea bicolor	0.35	0.40	*Neltuma glandulosa*	1.92	0.47
Ephedra antisyphilitica	0.56		*Tiquilia canescens*	11.46	0.48
Euphorbia antisyphilitica	0.67	0.25	*Viguiera stenoloba*		0.16
Guaiacum angustifolium	0.76	0.46			
Karwinskia humboldtiana	0.34		*Opuntia macrocentra*	13.19	8.10
Grasses (%)					
Aristida spp.	1.08	3.47	*Cynodon dactylon*	11.44	7.75
Arundo donax	2.04	1.02	*Erioneuron pulchellum*	13.72	11.57
Bouteloua curtipendula	6.35	3.79	*Heteropogon contortus*	0.43	2.25
Bouteloua gracilis	6.82	4.24	*Muhlenbergia porteri*	0.53	
Bouteloua ramosa	2.18	0.17	*Setaria leucopila*	0.48	0.22
Herbaceous plants (%)					
Abutilon wrigthii	2.86	17.88	*Parthenium confertum*	0.35	1.90
Allionia incarnata	0.54	0.57	*Selaginella spp*	0.53	1.01
Cologonia spp.	1.00	0.35	*Senecio flaccidus*		1.07
Croton dioicus	2.36	6.52	*Sida abutifolia*	1.01	0.53
Dyssodia setifolia		3.06	*Solanum elaeagnifolium*	1.76	1.50
Evolvulus alsinoides	0.50	0.19	Herbaceous plant not identified	0.75	1.63
Lesquerella fendleri		4.18			

on the relative abundance of plant traces in the samples, ranged between 64.5 % and 14.9 % in spring, with a mean of 35.4 ± 13.5 %, and between 72.5 % and 29.5 % in summer, with a mean of 49.2 ± 14.3 %; in this case, the difference between seasons was statistically significant ($P = 0.023$) (Figure 2).

Composition and consumption. The plant composition of the diet in spring was dominated by grasses (45.1 %), followed by shrubs (30.0 %), excluding the mountain prickly pear cactus (*O. macrocentra*), which accounted for 13.2 % and represented as much as 40 % of the diet at some sites. Herbaceous plants recorded the lowest percentage of the diet in spring (11.6 %).

In contrast, the most representative plants in the diet in summer were herbs (40.4 %), followed by grasses (34.5 %). In this same season, the proportion of shrubs, including prickly pear cactus, represented approximately 25 % of the diet (Figure 3).

The most frequent plant species in the equine diet in spring were the woody crinklemat (*Tiquilia canescens* [A. DC.] A.T. Richardson, 11.46 %) and the cenizo (*Leucophyllum frutescens* [Berland.] I.M. Jhonst., 5.26 %). Both species have soft, tomentose leaves that are particularly palatable among the species available this season. However, their consumption was significantly lower in summer ($P < 0.05$), likely because most species were highly dehydrated at that time.

In the case of grasses, spring and summer recorded a high consumption of fluffgrass (*Erioneuron pulchellum* [Kunth] Tateoka) and Bermuda grass (*Cynodon dactylon* [L.] Pers.) (Table 1). The former is abundant in rosette-shaped shrubland areas, while the latter is abundant on the banks of the Rio Grande, suggesting that equines probably move to the riverbanks in search of water, hence taking advantage of the local availability of this species. Other species also abundant in spring include the blue grama (*Bouteloua gracilis* [Kunth] Lag. ex Griffiths) and the sideoats grama (*B. curtipendula* [Michx] Torr.), both of which were abundant in the diet.

Regarding herbaceous plants, high consumption percentages of *Abutilon wrightii* A. Gray (17.9 %) and *Croton dioicus* Cav. (6.5 %) were observed in summer. Coinciding with the preferred shrubs in spring, these species have soft leaves in summer. The rest of the species in this group were recorded only at trace levels.

The cluster analysis between sites, seasons, and species yielded a cophenetic correlation value of 0.95, indicating that the dendrogram adequately represents the data clustering (Figure 4). Four well-defined groups were identified. The first included mountain prickly pear cactus, whose presence in the diet differed markedly from that of all other species, with a frequency of 65 % in both seasons. The second group consisted of *A. wrightii* and four species of grasses: *C. dactylon, E. pulchellum, B. curtipendula*, and *B. gracilis,* with Euclidean distances corresponding to relative frequencies in the diet ranging from 35 % to 55 %. The third group (between 20 % and 17 % Euclidean

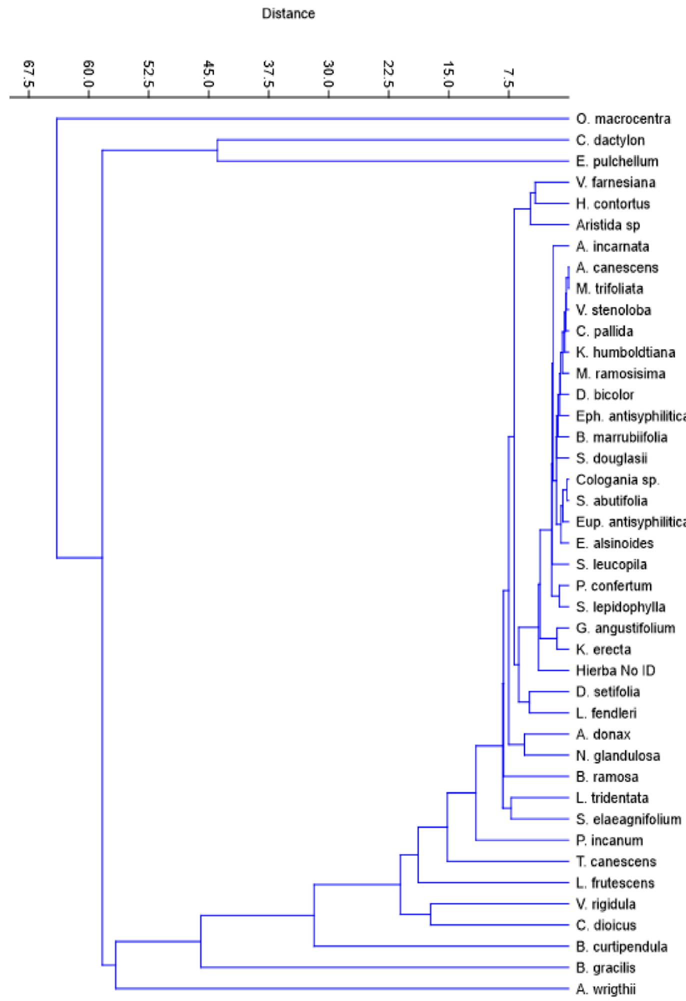

Figure 4. Hierarchical canonical correspondence analysis of the species that make up the diet of free-range equines during spring and summer in northern Coahuila.

distance) comprised blackbrush (*Vachellia rigidula* [Benth.]) and cenizo (*Leucophyllum. frutescens*), both shrub species, and *Croton dioicus*, a small semi-woody herbaceous species. These species are particularly important dietary components in the summer, after the rains. The fourth group comprised approximately 30 species, with a low contribution to the diet, all of which had Euclidean distances less than 15 %, indicating a low relative frequency and a limited contribution to the equine diet.

Discussion

The results of this study indicate that the composition of the diet of free-range equines varied between seasons, with a higher consumption of herbaceous plants in summer, clearly associated with higher humidity and, therefore, more abundant vegetation available for food. In contrast, grass consumption was significantly higher in spring, when it was dry and there were no fresh forage resources in the herbaceous stratum. The trend to increased forage availability after the summer rainy season was reported by Ochoa *et al.* (2023), who documented increased vegetation indices (NDVI) concurrent with higher precipitation levels in rainy years in the Chihuahuan desert. Peters *et al.* (2021)

also reported that heavy rainfall events led to a higher richness of plant species during summer in the same desert biome.

The above results coincide with previous studies that have described seasonal fluctuations in the diet of equines. It has been reported that the diet of donkeys during summer in the Sonoran and Mojave deserts accounted for between 33 % and 61 %, while in spring it fluctuated between 3 % and 30 % (Esmaeili *et al.* 2023). On the other hand, King and Schoenecker (2019), working in an equine herd management area in Colorado, United States, reported higher grass consumption in the horse diet in spring (68.7–78.5 %), similar to the numbers reported in the present study. A coincidence was reported in the proportion of shrub species consumed in spring and grass species in summer, both contributing approximately 30 % of the diet. This pattern is like the findings of Mikicic *et al.* (2023), who reported the preference of equines for open areas and a selective preference for herbaceous plants, with a consumption percentage of up to 80 %.

Regarding the ecological variable of species richness, 43 plant species were identified in the equine diet. This number is lower than the one reported by Esmaeili *et al.* (2023), who recorded 65 species, but similar to the number reported by Pansu *et al.* (2022), that is, 31 taxa (17–40 species) in the diet of large herbivores in southeast Africa.

These differences can be attributed to methodological factors. In particular, the microhistological analysis used in this study tends to underestimate the proportion of herbaceous species in the diet (43 species) compared to molecular methods such as those based on DNA markers (King and Schoenecker 2019). Additionally, the environmental context of this study, characterized by common land affected by severe drought, could limit the availability of plant resources, influencing the species richness observed in the diet.

In terms of dietary diversity, the Shannon-Wiener index calculated in this study was higher than that reported by Esmaeili *et al.* (2023), who documented H' values ranging from 1.40 to 1.94, and was close to the H' values documented by Pansu *et al.* (2022), which ranged from 1.58 to 2.57. These results suggest a moderate level of dietary diversity for equines in both seasons. However, contrary to our expectation, according to the hypothesis, no significant differences in dietary diversity were found between seasons. In addition to the diversity value, it is relevant to analyze the similarity in the composition of the diet, either between species, as addressed in most studies (MacCracken and Hansen 1981; Marshal *et al.* 2012; Gómez and Núñez 2016), or between seasons of the year, as in the present work. In the first case, the similarity analysis enables the identification of possible overlaps in the use of resources between species or vegetation strata, which can evidence ecological competition. This study did not compare competition with other herbivore species. However, given their body size, equines are potential competitors of domestic cattle and wild ungulates, such as bighorn sheep and mule deer, which thrive in the study area (Espinosa and Contreras 2010), although the latter two species exhibit foraging habits that mainly involve browsing (Hosten *et al.* 2007). It is worth noting that shrubs comprise between 15 % and 30 % of the equine diet, so active competition for this vegetation stratum is likely to occur to some extent.

Regarding competition with other animal species, the number of equines, both feral and domestic, has not been documented in detail anywhere in Mexico. However, estimating it is essential to prevent future conflicts with wildlife regarding competition not only for forage resources, but also for other components of the habitat. This is the case documented in the western United States, where the increase in the number of feral horses led to a decrease in the abundance of greater sage-grouse (*Centrocercus urophaisanus*) to approximately 2.5 % (Coates *et al.* 2021). The impact on the use of available space by this bird and the pronghorn (*Antilocapra americana*) has also been reported, with which equines compete not only for food, but also for displacement routes and watering troughs (Henning *et al.* 2022).

The similarity in diet between seasons of the year can help identify patterns of non-random site and food selection, likely determined by the availability of certain plant species. A study by Ochoa *et al.* (2017) in the same study region identified the plant species showing the highest ecological importance value, i.e., those best represented in terms of frequency, coverage, and density. Mesquite was the most important species, while prickly pear cactus was the most consumed species in the equine diet, being among the 10 species with the highest ecological importance value. Among grasses, blue grama produced the highest importance value (Ochoa *et al.* 2017), but fluffgrass was the species most consumed in spring and summer (13.7 % and 11.5 %, respectively). These three species were found in the equine diet, with prickly pear cactus and blue grama being the main components, at approximately 12 % and 6 %, respectively, implying that they are consumed in proportion to their abundance. In contrast, mesquite, despite its high importance value (71/100), only represented 1.9 % of the diet in spring, when it renews its leaves, suggesting non-random consumption.

The cluster analysis revealed two well-defined groups of plant food resources. The first included three of the five sites evaluated in summer and one in spring, which shared a similar diet composition, indicating that foraging sites could be selected based on the composition of plant species, namely *A. wrigthii* and four grass species (*B. gracilis, B. curtipendula, C. dactylon*, and *E. pulchellum*). The second cluster comprised five of the six sites evaluated in spring, showing a more diverse composition. The overall similarity of the diet between seasons was significantly different, with greater homogeneity in summer (50 %) than in spring. This similarity suggests a regularity in food selection in summer. Previous studies have reported a dietary overlap of up to 60 % between equines and mule deer (*Odocoileus hemionus*) in periods of high forage production (Marshal *et al.* 2012), as well as 50 % in the wet season and up to 70 % in the dry season between guanacos (*Lama guanicoe*) and feral donkeys in arid ecosystems (Gómez and Núñez 2016). Since equines are large herbivores, their intake rate and bite size can increase the likelihood of competition for forage resources with other species (MacCracken and Hansen 1981).

Finally, this study recorded a higher consumption of grass species in both seasons of the year, in terms of both the percentage in the diet composition and the relative frequency of consumption of species. This selection pattern is consistent with data reported in previous studies, where grass consumption by donkeys and zebras can exceed 50 % and even be the sole component in their diet under certain conditions (King and Schoenecker 2019; Pansu *et al.* 2022).

Conclusions

The consumption patterns observed in equines in the present study show seasonal variations in diet composition, with a higher consumption of herbaceous plants in summer and grasses in spring, possibly related to the increased availability of plants after the rainy season. Although these results differ from those reported in some previous studies, consistency was found in the consumption of shrubs and grasses, which account for approximately 30 % of the diet. These findings are consistent with observations suggesting that equines prefer open areas covered by herbaceous vegetation.

A total of 43 plant species were identified in the equine diet, which recorded a lower richness compared to some previous studies, likely due to differences in the methodology used and the environmental conditions at the study site, affected by drought and low availability of plant resources. Although prickly pear cactus (*O. macrocentra*) was identified as a major food source, grasses were the main functional group in the diet, highlighting their central role in the diet of these herbivores.

The results of this study provide relevant information on the diet of free-range equines in northern Mexico and underline the importance of considering these animals in the planning and management of grazing lands. Currently, this is practically not done, neither from an academic perspective nor for determining the productive parameters of grazing land (e.g., grazing coefficient, animal load, animal inventory) and is scarcely and poorly documented in decision-making in production units. Some of the regulatory initiatives could include the specific classification of grazing land for use by this type of livestock, reviewing ejido regulations to adjust the number of equine heads using grazing land at a given space and time, or implementing ethical measures for the control of feral populations that disrupt habitats and cause damage to other species.

Given the size and feeding habits of equines and their competition or overlap with other domestic and wild herbivorous species, this interaction should be considered in future studies, especially when evaluating the feasibility of conservation strategies or reintroduction of wildlife species, since their coexistence with equines could reduce the availability of resources or even jeopardize the survival of other species (Beck *et al.* 2024).

Unlike other countries such as the United States, where feral equine management is regulated and population estimates are conducted to assess their impact on ecosystems (Scasta *et al.* 2016), in Mexico, there is scarce information and a mixed social perception about donkeys, horses, and mules. Therefore, it is essential to improve our understanding of their ecology and develop appropriate management strategies to mitigate the potential adverse effects on natural ecosystems.

Acknowledgments

The authors wish to especially thank the Ocampo direction of the Flora and Fauna Protection Area of the National Commission of Natural Protected Areas, the conservation management of the El Carmen Natural Reserve, and the inhabitants of the ejidos Jaboncillo Grande, La Unión y El Olán, and San Vicente y Zacatonal, for facilitating access to their land and providing support for field data collection. María Elena Sánchez-Salazar translated the manuscript into English.

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Associated editor: Luis Manuel Garcia-Feria
Submitted: May 2, 2025 Reviewed: June 25, 2025
Accepted: July 7, 2025 Published on line: August 4, 2025