Revista Mexicana de Ciencias Forestales Vol. 14 (79)
Septiembre - Octubre (2023)

DOI: 10.29298/rmcf.v14i79.1358

Research article

Competencia alimentaria entre el berberisco (*Ammotragus lervia* Pallas, 1777) y el borrego cimarrón (*Ovis canadensis* Shaw, 1804) en Coahuila

Food competition between Barbary sheep (*Ammotragus lervia* Pallas, 1777) and Bighorn sheep (*Ovis canadensis* Shaw, 1804) in *Coahuila* State

Alondra Rodríguez García[1], Fernando N. González Saldívar[1]*, César M. Cantú Ayala[1], José I. Uvalle Sauceda[1]

Fecha de recepción/Reception date: 14 de marzo de 2023.
Fecha de aceptación/Acceptance date: 17 de agosto de 2023.

[1]Universidad Autónoma de Nuevo León, Facultad de Ciencias Forestales. México.

*Autor para correspondencia; correo-e: fer1960_08_10@hotmail.com.
*Corresponding author; e-mail: fer1960_08_10@hotmail.com.

Abstract

The botanical composition of diet and trophic competition between the bighorn sheep (*Ovis canadensis*) and the barbary sheep (*Ammotragus lervia*) were determined during 2021 to 2023, in *San Juan* hunting ranch, at northeast *Coahuila* State. The rosetophyllous desert scrub was the most extended vegetation type in lower regions, while the chaparral was the most extended in the higher region of the *Sierra*, with a total record of 52 and 48 plant species, respectively. The diet of the barbary sheep consisted of 31 species, being 22 of them consumed in spring, 18 in summer, 19 in autumn and 22 in winter. The diet of the bighorn sheep consisted of 40 species, being 33 consumed in spring, 24 in summer, 20 in autumn and 27 in winter. The lowest competition for food between both bovid species was found in spring and the highest in summer with 40.76 and 64.97 %, respectively. Based on these results, an annual average coincidence of 52 % of the food between both species was determined. It can be concluded that the food competition rate between both species is medium to high depending on the year season.

Key words: Wild sheeps, exotic species, native species, rosetophyllous desert scrub, microhistology, diet similarity.

Resumen

Se determinó la composición botánica de la dieta y la competencia trófica entre el borrego cimarrón (*Ovis canadensis*) y el borrego berberisco (*Ammotragus lervia*) durante los años 2021 a 2023 en el rancho cinegético San Juan, en el noreste de Coahuila. El matorral desértico rosetófilo fue el tipo de vegetación más extendido en las regiones bajas, mientras que el chaparral lo fue en la región alta de la Sierra; se registró un total de 52 y 48 especies vegetales, respectivamente. La dieta del borrego berberisco estuvo compuesta por 31 especies, 22 de ellas las consumió en primavera, 18 en verano, 19 en otoño y 22 en invierno. La dieta del borrego cimarrón estuvo compuesta por 40 especies, 33 fueron su alimento en primavera, 24 en verano, 20 en otoño y 27 en invierno. La menor competencia por alimento entre ambas especies de bóvidos se presentó en primavera y la mayor en verano con 40.76 y 64.97 % de coincidencia en su dieta, respectivamente. Con base en estos resultados, se determinó una coincidencia promedio anual de 52 % del alimento entre ambas especies de

bóvidos. Se concluye que la tasa de competencia alimentaria entre los dos taxones es de media a alta en función de la época del año.

Palabras clave: Borregos silvestres, especies exóticas, especies nativas, matorral desértico rosetófilo, microhistología, similitud de dietas.

Introduction

One of the main threats to biodiversity in Mexico is the introduction of exotic species, either intentionally or accidentally, which develop invasive behavior and thus manage to displace native species.

The Barbary sheep (*Ammotragus lervia* Pallas, 1777) was introduced to the North and Center of the country for use purposes. Currently, it can be found in 38 Management Units for the Conservation of Wildlife or UMAs (for its acronym in Spanish); however, the main feral populations gather in the mountains of some federal entities such as *Sonora*, *Coahuila*, *Nuevo León* and *Chihuahu*a (Medellín, 2005).

One way in which it is possible to know to what extent exotic species affect native ones, is by knowing the similarity and preference of the diet. In this regard, research has been carried out on this topic among exotic and native species (Barrett, 1967; Tapia and Mellink, 1989; Jackley, 1991; Gastelum, 2020; Gastelum-Mendoza *et al.*, 2023), and specifically, in the botanical composition of the diet of Barbary sheep and Bighorn sheep (Medellín, 2005; Guerrero-Cárdenas *et al.*, 2016, 2018; Gastelum-Mendoza *et al.*, 2023).

Vegetation cover, as an element of the habitat that provides food and different types of cover for wildlife, is a fundamental element, the importance of which varies depending on the requirements of the species (Ramírez, 2004; Fulbright and Ortega-Santos, 2006). In Northern Mexico and the Southwestern United States of America, Bighorn sheep (*Ovis canadensis* Shaw, 1804) inhabit arid climates with

rugged topography characterized by low-lying cover that provides adequate visibility and escape terrain (Tarango *et al.*, 2002; Escobar-Flores *et al.*, 2015). Likewise, the Barbary sheep in North Africa is adapted to an extreme arid climate, characterized by mountain ranges with low vegetation cover (Nowak, 1991).

The botanical composition of the diet serves as an instrument to assess and determine the compatibility that exists between wildlife and its habitat. Knowledge of the botanical and nutritional composition of the diet is essential to establish carrying capacity in UMA management plans (Villarreal-Espino-Barros *et al.*, 2008). There are a good number of studies on the diets of both species, but very few studies to know the competition between both and those that exist have been carried out in the United States of America (Smith and Krausman, 1988; Etchart *et al.*, 2016).

Barbary sheep may be competing for food resources with the native species of Northeast Mexico, which feed on grasses and herbaceous plants, and may be exerting pressure on their populations and modifying the population dynamics of both groups (plants and animals), which can affect deer species and Bighorn sheep in particular.

The objective of this study is, first, to estimate the diets of both sheep, to obtain the degree of diet similarity between both cattle, and finally, to know if there is competition for food between both species.

Materials and Methods

Study area

The study was carried out in the 2021-2023 period in the *Rancho San Juan* Management Unit for the Conservation of Wildlife (UMA), at 26°49´12.34" North and 100°58´43.52" West (Figure 1), which is located 42 km in a straight line east of the city of *Monclova*, state of *Coahuila*, Mexico.

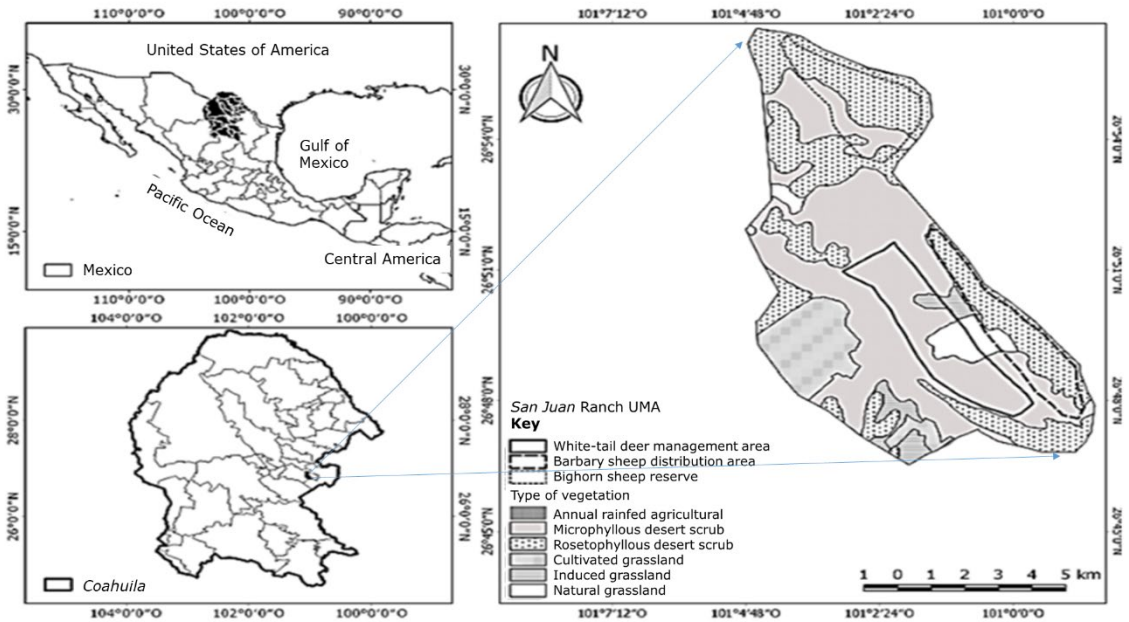

Figure1. Location of *Rancho San Juan* study area in *Monclova*, state of *Coahuila*, Mexico.

The *Sierra Las Hormigas* is located in this UMA, a place where introduced populations from *Sonora* and Texas of Bighorn sheep and Barbary sheep live and develop, respectively, under semi-captivity conditions, and with the same habitat conditions and types of vegetation. The UMA has an area near 4 500 ha and the *Sierra Las Hormigas* has an area of approximately 1 200 ha for the Barbary and

around 500 ha for the Bighorn, both separated only by a 2.8 m high fence, with an elevation of about 1 100 masl in the highest parts. The dominant vegetation is the rosetophillous desert scrub and chaparral (Gastelum, 2020).

Microhistological technique

For the identification of the plants that make up the diet of bovids, the microhistological technique was used (Peña-Neira and Habib de Peña, 1980; Catán *et al.*, 2003) on the species collected from the rosetophyllous desert scrub and chaparral, which allows comparing the presence of plant residues in fecal material through a reference photographic catalog that shows the microscopic epidermal structures of each plant; with this information, the data that is statistically analyzed is generated.

To obtain the data in the field, the collection of fresh fecal samples was carried out, approximately 70 from each sheep, for each seasons of the year.

The Past 3 program was used in the statistical analyzes of this study (Hammer *et al*., 2001). From the accumulated frequency, the contribution of each plant species in the diet was estimated (Peña-Neira and Habib de Peña, 1980).

On this basis (*FA*) and the total number of fields analyzed (*N*), the frequency (*F*) was calculated as follows:

$$F = \frac{FA}{N} \qquad (1)$$

Where:

F = Frequency

FA = Cumulative frequency

N = Total number of analyzed fields

Once the frequency was known, the relative density (%) was determined and the result of this parameter was used to express the botanical composition of the diet. This calculation was made by season of the year, using the following equation (Peña-Neira and Habib de Peña, 1980):

$$DRa = \frac{D_a}{\sum_i^n Di} \quad (2)$$

Where:

DRa = Relative density of the species

D_a = Density of the species

Di = Density of each species

To know the existing food competition between the study species, the Sørensen index and the Jaccard index (Alanis *et al.*, 2020) were used. For the Sørensen index the following formula was used:

$$I_s = \frac{2c}{a+b} \times 100 \quad (3)$$

Where:

I_s = Sørensen similarity index

a and *b* = Number of species in samples *a* and *b*, respectively

c = Number of shared species by the two samples

It is very similar to the Sørensen similarity coefficient for qualitative data, however, this index is not related to the species but to their abundances.

For Jaccard Index, the following formula was used (Alanís *et al.*, 2020):

$$I_j = \frac{c}{a+b-c} \times 100 \qquad (4)$$

Where:

I_j = Jaccard index

a = Number of species at site A

b = Number of species at site B

c = Number of species present in both sites A and B, that is, they are shared

The range of this Index goes from zero (0 % competition), when there are no shared species, to one (100 % competition), when the two diets share the same species. This Index measures differences in the presence or absence of species.

Diet similarity index

To determine the similarity and competition between diets, the Kulcynski Index (Saiz, 1980) was used, which at first was used to observe the degree of similitude between plant communities, but it is also used to know the overlapping of diets. The formula for this calculation is as follows:

$$IS = \frac{\sum 2W}{\sum (a+b)} \times 100 \qquad (5)$$

Where:

IS = Similarity Index

W = Lower percentage of a certain plant when comparing their percentages of consumption by two different animals

(*a*+*b*) = Sum of these percentages

Results

Diet of the two species of sheep

Barbary sheep diet composition. The first place of annual consumption was occupied by the shrubs with an average of 39.87 %, followed by the grasses with 28.02 %, the herbaceous occupied the third place with 20.68 %, the tree species with 6.69 % and finally the succulent species with 4.74 % (Table 1).

Table 1. Main species with their percentage present in the diet of the Barbary sheep (*Ammotragus lervia*, Pallas 1777) in each season of the year in the *Rancho San Juan*, *Monclova*, *Coahuila*, Mexico.

Species/Season	Spring (%)	Summer (%)	Autumn (%)	Winter (%)
1. *Acacia berlandieri* Benth.		4.97	1.85	
2. *Acacia rigidula* Benth.	12.07	10.6	9.61	18.23
3. *Aloysia macrostachya* (Torr.) Moldenke	16.1	3.65	3.8	8.48
4. *Aristida adscensionis* L.	16.1	9.98		11.31
5. *Bothriochloa saccharoides* (Sw.) Rydb.		2.04	6.87	1.39
6. *Bouteloua curtipendula* (Michx.) Torr.	1.98	4.97	4.8	3.8
7. *Bouteloua gracilis* (Kunth) Lag. *ex* Griffiths	11.3	14.47	21.06	8.48
8. *Caesalpinia mexicana* A. Gray	1.31	4.97	4.8	6.34
9. *Castela texana* (Torr. & A. Gray) Rose	10.53	2.04		3.8
10. *Chamaecrista greggii* (A. Gray) Pollard *ex* A. Heller	6.83	17.95	1.85	7.94
11. *Euphorbia antisyphilitica* Zucc.	3.32		6.87	2.33
12. *Euphorbia polycarpa* Benth.		8.18	6.87	
13. *Forestiera angustifolia* Torr.	0.65	3.11	0.46	
14. *Larrea tridentata* (DC.) Coville	1.98	6.43	4.8	
15. *Leucophyllum frutescens* (Berland.) I. M. Johnst.	0.65		0.46	0.46
16. *Medicago sativa* L.	1.31		3.31	5.3
17. *Opuntia microdasys* (Lehm.) Pfeiff.	1.98		6.35	9.59
18. *Tecoma stans* (L.) Juss. *ex* Kunth	0.65	1.02	10.17	0.46

The most important species for their annual consumption in the diet of the Barbary and the stratum to which it belongs were: *Bouteloua gracilis* (Kunth) Lag. *ex* Griffiths (13.82 %) of the grass, *Acacia rigidula* Benth. (12.63 %) of the shrubs, *Aloysia macrostachya* (Torr.) Moldenke (8.01 %) of the herbs, *Opuntia microdasys* (Lehm.) Pfeiff. (4.48 %) was the most important of the succulents and *Tecoma stans* (L.) Juss. *ex* Kunth (3.08 %) of the trees.

The shrubby species had the first place in the plant material consumed in almost all seasons of the year, only during fall they were replaced by the herbaceous, a fact that could be explained by the fact that autumn is the rainy season and the first species to proliferate in the area were the herbs, which were consumed mainly by the barbary sheep.

Bighorn sheep diet composition. As previously indicated with the Barbary sheep, the first place of annual consumption was occupied by shrubs with an average of 39.30 % followed by trees with 20.55 %, third place was occupied by succulents with 17.46 %, grasses represented fourth place with 15.44 % and finally herbaceous with 7.25 % (Table 2).

Table 2. Main species in the composition of the diet of the bighorn sheep (*Ovis canadensis*, Shaw 1804) during the four seasons of the year in the *Rancho San Juan*, *Monclova*, *Coahuila*, Mexico.

Species/Season	Spring (%)	Summer (%)	Autumn (%)	Winter (%)
1. *Acacia berlandieri* Benth.	1.77	7.43	8.97	4.62
2. *Acacia rigidula* Benth.	22.36	12.22	21.22	16.66
3. *Acourtia runcinata* (D. Don) B. L. Turner	2.35	-	3.05	0.75
4. *Agave* L. sp.	0.59	4.65	10.37	2.28
5. *Aloysia macrostachya* (Torr.) Moldenke	0.59	4.65	-	1.51

6. *Bouteloua adscensionis* L.	1.77	8.76	-	6.23
7. *Bouteloua curtipendula* (Michx.) Torr.	8.74	3.86	8.29	10.4
8. *Bouteloua gracilis* (Kunth) Lag. *ex* Griffiths	0.59	1.52	1.81	0.75
9. *Castela texana* (Torr. & A. Gray) Rose	1.17	1.52	0.6	1.51
10. *Croton incanus* Kunth	0.59	4.65	6.93	2.28
11. *Dasylirion berlandieri* S. Watson	3.59	0.76	1.2	3.83
12. *Euphorbia antisyphilitica* Zucc.	4.21	5.46	0.6	2.28
13. *Forestiera angustifolia* Torr.	1.17	3.05	-	-
14. *Gochnatia hypoleuca* (DC.) A. Gray	-	4.65	5.88	10.4
15. *Guaiacum angustifolium* Engelm.	2.97	2.29	-	0.75
16. *Larrea tridentata* (DC.) Coville	-	2.29	2.41	2.28
17. *Leucophyllum frutescens* (Berland.) I. M. Johnst.	2.97	1.52	1.81	4.62
18. *Opuntia engelmannii* Salm-Dyck *ex* Engelm.	-	6.27	-	1.51
19. *Opuntia leptocaulis* DC.	2.97	4.65	0.6	4.62
20. *Opuntia microdasys* (Lehm.) Pfeiff.	4.84	11.34	5.88	3.03
21. *Tecoma stans* (L.) Juss. *ex* Kunth	21.52	4.65	12.53	12.14

For the Bighorn sheep, the main species consumed annually and the stratum to which they belong were: *Acacia rigidula* (18.12 %) belonging to the shrubs, *Tecoma stans* (12.71 %) of the trees, *Bouteloua curtipendula* (Michx.) Torr. (7.82 %) to the grasses, *Opuntia microdasys* (6.27 %) was the most important of the succulents and *Croton incanus* Kunth (3.61 %) of the herbaceous stratum.

This sheep also showed a greater preference for the shrubby ones, which occupied in almost all the seasons of the year, the first place of the plant material consumed, however, the arboreal ones also occupy an important place in the diet of this species.

The Barbary showed a greater preference for *Bouteloua gracilis* and *Acacia rigidula*, while the Bighorn for *Acacia rigidula* and *Tecoma stans*. The rest of the species, while

a Barbary sheep consumes them in high quantities, the Bighorn consumes them in low quantities, in such a way that there is less competition between them (Figure 2).

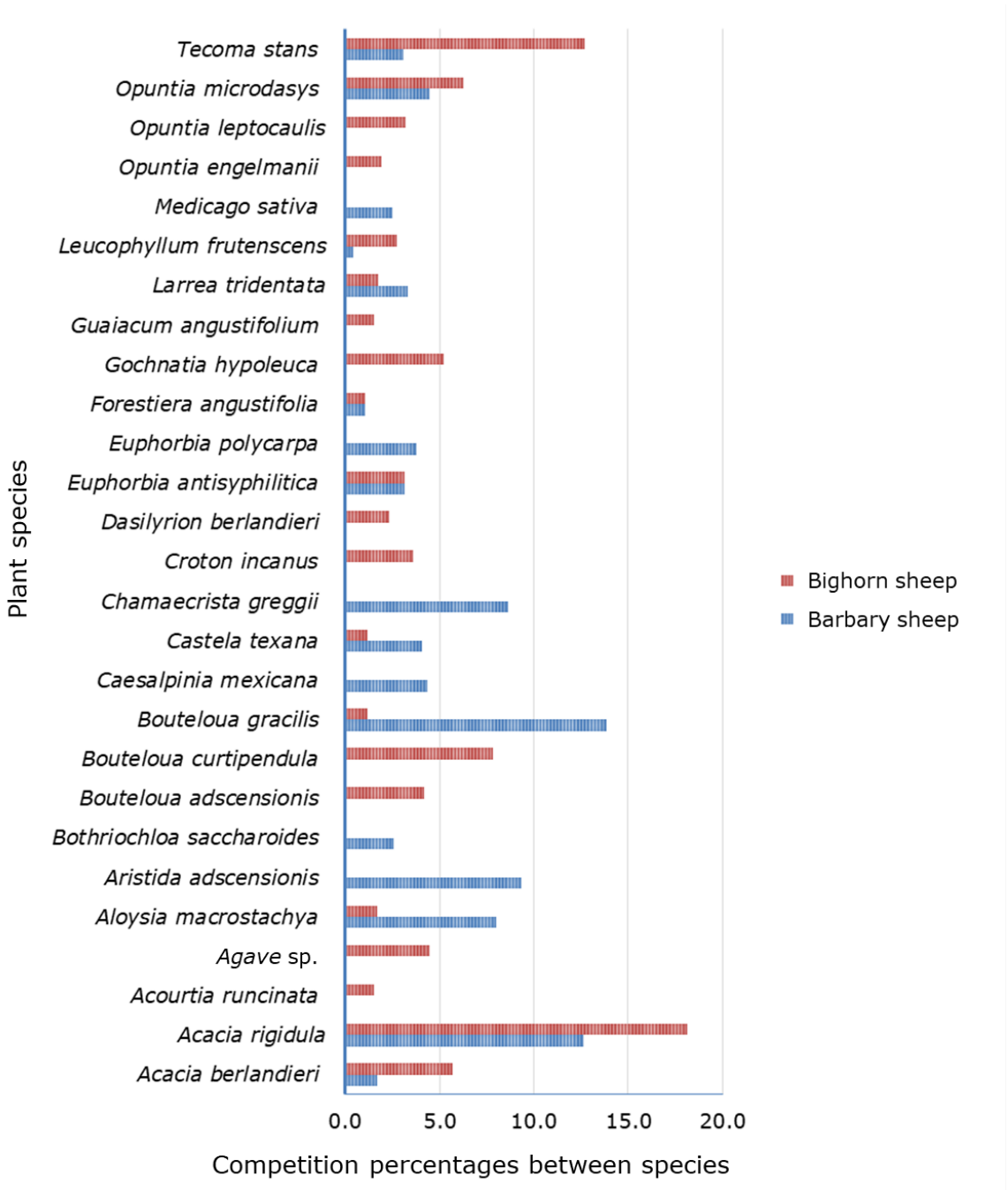

Figure 2. Degree of competition for the main species consumed in the year by Barbary sheep (*Ammotragus lervia*, Pallas 1777) and Bighorn sheep (*Ovis canadensis*, Shaw 1804) in the study area with rosetophyllous scrub and chaparral.

Comparison and similarity of diets between sheep

Diet similarity index (Sørensen and Jaccard indexes). The results for the Sørensen index show that the highest competition between both species occurred in the winter season with 65 % and that the lowest value of competition was in the autumn season with 41 %. This is confirmed by the Jaccard index for the winter season with a result of 48 % of the plants registered in the study area. The season of the year with the lowest degree of competition was autumn with 26 %. Through this index it was also determined that competition is low between both species, based on the reference values.

This can be explained by the fact that the rainy season occurs in the autumn season for the Northeast of Mexico, therefore, there was a higher biomass production in the study area, such as herbaceous and grass species, while in the summer season, there was a low presence of species of this type of stratum, which caused the sheep to have more consumption and preference over specimens of shrubs and trees, since they were the plants that remained present and with greater availability in the habitat, which gave rise to greater competition between both mammals for their consumption.

Food similarity according to the Kuczynski Index. Below is the list of species in the diet of both sheep, as well as the season when consumption and similarity were recorded in both (Table 3).

Table 3. Percentages of similarity in the diet of some plants between the Barbary sheep (*Ammotragus lervia*, Pallas 1777) and the Bighorn sheep (*Ovis canadensis*, Shaw 1804) at *Rancho San Juan*, *Monclova*, *Coahuila*, Mexico.

Species/Season	Spring %	Summer %	Autumn %	Winter %
1. *Acacia berlandieri* Benth.	-	80	34	-
2. *Acacia rigidula* Benth	-	93	62	96
3. *Aloysia macrostachya* (Torr.) Moldenke	7	88	-	30
4. *Aristida* adscensionis L.	20	93	-	71
5. Bouteloua curtipendula (Michx.) Torr.	37	87	73	54
6. *Bouteloua gracilis* (Kunth) Lag. *ex* Griffiths	10	19	16	16
5. *Castela texana* (Torr. & A. Gray) Rose	20	85	-	57
6. Chamaecrista greggii (A. Gray) Pollard *ex* A. Heller	-	8	-	32
7. *Euphorbia antisyphilitica* Zucc.	88	-	16	99
8. *Forestiera angustifolia* Torr.	71	99	-	-
9. *Gochnatia hypoleuca* (DC.) A. Gray	-	-	-	37
10. *Larrea tridentata* (DC.) Coville	-	53	67	-
11. *Leucophyllum frutescens* (Berland.) I. M. Johnst.	36	-	41	18
12. *Opuntia microdasys* (Lehm.) Pfeiff.	82	-	96	48
13. *Tecoma stans* (L.) Juss. *ex* Kunth	6	36	90	7
14. *Ziziphus obtusifolia* (Hook. *ex* Torr. & A. Gray) A. Gray	71	-	-	90
Mean by season (%)	40.76	64.98	54.97	51.08

To evaluate this competition, the Kuczynski Index was applied and in this way the similarity between diets by species and by season was determined, to later evaluate the percentage of similarity for each of them, as well as the annual percentage.

The species with the greatest similarity in the diet between both sheep in the different seasons of the year, was made up of *Euphorbia antisyphilitica* Zucc. for the spring, this being the highest in percentage of similarity with a value of 88 %, *Forestiera angustifolia* Torr. with 99 % in the summer, *Opuntia microdasys* with 96 % in autumn, and *Acacia rigidula* with 96 % in winter. These were the most representative species in each of the stations based on their percentage of similarity in consumption (Table 3). An annual similarity between diets of both sheep was obtained with a value of 52.95 %, which represents a medium to high competition.

Based on the results obtained by the Kuczynski Index, it was determined that the highest percentage of competition by season of the year was in summer, with a value of 64.98 %, while the lowest percentage was in spring, with a value of 40.76 %. The species for which both species of sheep competed throughout the year, was the shorty brown (*Acacia rigidula*), since for the Barbary it had the second place and for the Bighorn the first place in its diet (Figure 2). The average annual percentage of competition was 52.95 %. With this result it was determined that the degree of annual competition between both species can be classified as medium to high.

Discussion

The most important species referring to their ecological characteristics in the distribution area of the Barbary sheep, in order of importance, were those of the shrubby and herbaceous stratum. The index values showed that there is a large number of these in the area, with different degrees of dominance, since they all recorded different levels of abundance, and only a part of them were the most representative.

The variability or availability of the species can be affected and determined by the rainy and dry seasons. This coincides with what was described by Guerrero-Cárdenas *et al.* (2016) on the composition and selection of the diet of the Bighorn sheep when analyzing the patterns of use, as well as the availability of plant species seasonally present in the area; 63 species were identified in 2010 and 50 in 2011. Shrubs were the dominant life forms; the highest numbers of abundance of species in the area were recorded in autumn 2010 and winter 2011.

In the present study, the shrubs occupied the first place with almost 40 % of the diet of the Barbary sheep, so it can be said that this species of sheep is more browsing than grazing in Northern Mexico compared to the Barbary sheep in the *Bou Hedma* National Park of Tunisia, which has a clear preference for grasses (67 % of the annual diet), followed by shrubs (17 %) and herbaceous (16 %), which identifies this ungulate as a grazer (Ben and Nouira, 2015). In the Edwards Plateau region of Texas, its annual diet consisted of 61 % grasses, 21 % shrubs and 18 % herbaceous, which also confirms it as a grazer in the United States of America (Ramsey and Anderegg, 1972).

Shrubs in all seasons of the year were the most consumed with significant percentages for both sheep, which is similar to what was proposed by Gastelum-

Mendoza *et. al.* (2023) in the sense that shrubs are the most important form of life in the structure of the Vegetation of the habitat of the Bighorn sheep in the Northeast of Mexico. Guerrero-Cárdenas *et al.* (2016) also assume that the shrubby ones were the most consumed, constituting 62.1 % in the entire diet. According to Hanley (1982), its large mandibles and molars and its large ruminous-reticular volume are considered adaptations to use grasses with a high cellulose content. However, Gastelum (2020) observed for the habitat of the desert Bighorn sheep in Northeast of Mexico, dominated by shrubby communities with very little grass cover, that its diet is composed of shrubs, subshrubs, herbaceous plants, and trees, and a lower proportion of grasses (Miller and Gaud, 1989; Gastelum, 2015, 2020; Gastelum-Mendoza *et al.*, 2023).

It is important to underline that the shrubs occupied the first place in the diet of these species, which coincides with what was proposed by Medellín (2005), who mention that the diet of the Barbary sheep is mainly composed of small shrubs, grasses and herbaceous plants, which can get up on its hind legs to browse the foliage of small trees.

Conclusions

The two species of wild ungulates studied in this work showed a very similar composition in their annual diet, since both sheep have a preference for species from the shrub and tree strata.

According to the food competition analysis, the Barbary sheep and the Bighorn sheep show a competition level from medium to high.

The seasons in which these species have more food competition are in winter and autumn, based on the Sørensen and Jaccard indexes. Both taxa of sheep compete for food resources according to the availability they had in the studied habitat.

The two sheep species show a preference for shrub and tree species, but their degree of competition is not high enough to affect one species to the other; the degree of selection and the plants chosen for consumption are not determined by the plants themselves, however, competition occurs only when both sheep have the same resources, and these are limited or reduced within their habitat.

Acknowledgements

The authors thank Mr. Gerardo Benavides Pape, for allowing to carry out this study at his *Rancho San Juan* in *Monclova*, *Coahuila*. To Ing. Vladimir Lara, technical manager of the same, for his support in the field, in addition to taking some data when it was not possible to be at the aforementioned ranch. The authors are specially greatful to him for all his support. Also, the auhors acknowledge Dr. Eloy Alejandro Lozano C., technical manager of the same for having managed the entry permits to this UMA and for his support in the accomplishment of the study.

Conflict of interests

It is declared that there is no conflict of interest between the authors of this document.

Contribution by author

Alondra Rodríguez García: Master's student at FCF-UANL, she contributed to data collection in the field, manuscript writing, correction support, and data analysis; Fernando N. González Saldívar: review of the manuscript and its correction, support in collecting field data and data analysis; César M. Cantú Ayala: review of the analysis of the field data, structure of the manuscript and its review; José I. Uvalle Sauceda: support in collecting field data, structure of the manuscript and its review.

References

Alanís R., E., A. Mora O. y J. S. Marroquín de la F. 2020. Muestreo Ecológico de la Vegetación. Editorial Universitaria de la Universidad Autónoma de Nuevo León. Monterrey, NL, México. 252 p.

Barrett, R. H. 1967. Some comparisons between the Barbary sheep and the desert Bighorn. In: Yoakum, J., C. Hansen, N. Simmons, W. Graf and R. Brechbill (Edits.). Desert Bighorn Council 1967 Trnasactions 11th Annual Meeting. Desert Bighorn Council. Kingman, AZ, United States of America. pp. 16-26.

Ben M., J. and S. Nouira. 2015. Food habits of the aoudad *Ammotragus lervia* in the Bou Hedma mountains, Tunisia. South African Journal of Science 111(11/12):1-5. Doi: 10.17159/sajs.2015/20140448.

Catán, A., C. A. M. Degano y L. Larcher. 2003. Modificaciones a la técnica microhistológica de Peña Neira para especies forrajeras del Chaco Semiárido Argentino. Revista de Ciencias Forestales-Quebracho 10:71-75. https://www.redalyc.org/pdf/481/48101008.pdf. (8 de marzo de 2022).

Escobar-Flores, J. G., S. Álvarez-Cárdenas, R. Valdez, J. Torres R., … y R. Martínez G. 2015. Detección de las preferencias de hábitat del borrego cimarrón (*Ovis canadensis cremnobates*) en Baja California, mediante técnicas de teledetección satelital. Therya 6(3):519-534. http://www.redalyc.org/articulo.oa?id=402341557003. (10 de marzo de 2022).

Etchart, J., R. O´shaughnessy and S. Avila. 2016. Interactions of Aoudad & Bighorn Sheep Trans-Pecos Region of Texas. Texas Wildlife:42-43. https://bri.sulross.edu/pubs/borderlandsnews/BN_2016_7.pdf. (10 de marzo de 2022).

Fulbright, T. E. and J. A. Ortega-Santos. 2006. White-tailed deer habitat: ecology and management in rangeland. Texas A & M University Press. College Station, TX United States of America. 265 p.

Gastelum M., F. I. 2015. Dieta y segregación del borrego cimarrón (*Ovis canadensis mexicana* Merriam, 1901), en Sonora, México. Tesis de Maestría. Postgrado en Innovación en Manejo de Recursos Naturales, Colegio de Postgraduados Campus San Luis Potosí. Salinas de Hidalgo, SLP, México. 35 p. http://colposdigital.colpos.mx:8080/jspui/bitstream/10521/2648/1/Tesis_Fernando%20Isaac%20Gastelum%20Mendoza-2014.pdf. (22 de marzo de 2022).

Gastelum M., F. I. 2020. Ecología trófica y evaluación del hábitat de *Ovis canadensis mexicana*, *Ammotragus lervia* y *Odocoileus virginianus texanus* en Coahuila, México. Tesis de Doctorado. Facultad de Ciencias Forestales, Universidad Autónoma de Nuevo León. Linares, NL, México. 171 p. http://eprints.uanl.mx/21017/1/1080314673.pdf. (22 de marzo de 2022).

Gastelum-Mendoza, F. I., F. N. González-Saldívar, E. A. Lozano-Cavazos, J. I. Uvalle-Sauceda, R. Serna-Lagunes y C. M. Cantú-Ayala. 2023. Hábitos forrajeros de *Ammotragus lervia* (Pallas, 1777) (Artiodactyla: Bovidae) en matorral desértico rosetófilo de Coahuila, México. Acta Zoológica Mexicana (nueva serie) 39:1-17. Doi: 10.21829/azm.2023.3912581.

Guerrero-Cárdenas, I., S. Álvarez-Cárdenas, S. Gallina, P. Corcuera, R. Ramírez-Orduña e I. Tovar-Zamora. 2018. Variación estacional del contenido nutricional de la dieta del borrego cimarrón (*Ovis canadensis wemsi*), en Baja California Sur, México. Acta Zoológica Mexicana (nueva serie) 34:1-18. Doi: 10.21829/azm.2018.3412113.

Guerrero-Cárdenas, I., S. Gallina, P. Corcuera, S. Álvarez-Cárdenas and R. Ramírez-Orduña. 2016. Diet composition and selection of the bighorn sheep (*Ovis canadensis*) in Sierra El Mechudo, Baja California Sur, México. Therya 7(3):423-437. Doi: 10.12933/therya-16-394.

Hammer, Ø, D. A. T. Harper and P. D. Ryan. 2001. Past: Paleontological Statistics Software Package for Education and Data Analysis. Palaeontologia Electronica 4(1):1-9. https://palaeo-electronica.org/2001_1/past/past.pdf. (8 de marzo de 2022).

Hanley, T. A. 1982. The nutritional basis for food selection by ungulates. Journal of Range Management 35(2):146-151. Doi: 10.2307/3898379.

Jackley, J. J. 1991. Dietary overlap among axis, fallow, sika and white-tailed deer in the Edwards Plateau Region of Texas. Thesis of Master of Science. Texas Tech University. Lubbock, TX, United States of America. 189 p. http://hdl.handle.net/2346/59839. (12 de mayo de 2022).

Medellín L., R. A. 2005. Vertebrados superiores exóticos en México: Diversidad, distribución y efectos potenciales. Instituto de Ecología de la Universidad Nacional Autónoma de México. Coyoacán, D. F., México. 27 p.

Miller, G. D. and W. S. Gaud. 1989. Composition and variability of desert bighorn sheep diets. The Journal of Wildlife Management 53(3):597-606. Doi: 10.2307/3809182.

Nowak, R. M. 1991. Walker's mammals of the world. Johns Hopkins University Press. Baltimore, MD, United States of America. 1629 p.

Peña-Neira, J. M. y R. Habib de Peña. 1980. La técnica microhistológica: Un método para determinar la composición botánica de la dieta de herbívoros. Instituto Nacional de Investigaciones Pecuarias y Secretaría de Agricultura y Recursos Hidráulicos. México, D. F., México. 82 p.

Ramírez L., R. G. 2004. Nutrición del venado cola blanca. Universidad Autónoma de Nuevo León, Unión Ganadera Regional de Nuevo León y Fundación Produce. Monterrey, NL, México. 240 p.

Ramsey, C. W. and M. J. Anderegg. 1972. Food habits of an Aoudad sheep, *Ammotragus lervia* (Bovidae), in the Edwards Plateau of Texas. The Southwestern Naturalist 16(3-4):267-280. Doi: 10.2307/3670063.

Saiz, F. 1980. Experiencias en el uso de criterios de similitud en el estudio de comunidades. Archivos de Biología y Medicina Experimentales 13:387-402. http://www.biologiachile.cl/biological_research/VOL13_1980/N4/SAIZ_F.pdf. (12 de mayo 2022).

Smith, N. S. and P. R. Krausman. 1988. Desert Bighorn Sheep: A guide to select management practices. Fish and Wildlife Service, U. S. Department of the Interior. Washington, DC, United States of America. 27 p.

Tapia S., G. y E. Mellink B. 1989. Selección de hábitat por trece ungulados y un ave corredora en una reserva en el desierto sonorense. In: Facultad Médica de Zootecnia. Memorias del VII Simposio sobre Fauna Silvestre. Universidad Nacional Autónoma de México. Coyoacán, D. F., México. pp. 222-241.

Tarango, L. A., P. R. Krausman, R. Valdez and R. M. Kattnig. 2002. Research observation: Desert bighorn sheep diets in North-western Sonora, Mexico. Journal of Range Management 55(6):530-534. Doi: 10.2307/4003995.

Villarreal-Espino-Barros, O. A., L. E. Campos-Armenda, T. A. Castillo-Martínez, I. Cortés-Mena, F. X. Plata-Pérez y G. D. Mendoza-Martínez. 2008. Composición botánica de la dieta del venado temazate rojo (*Mazama temama*), en la Sierra

Nororiental del Estado de Puebla. Universidad y Ciencia 24(3):183-188. http://www.redalyc.org/articulo.oa?id=15424302. (1 de abril de 2022).

Todos los textos publicados por la **Revista Mexicana de Ciencias Forestales –**sin excepción– se distribuyen amparados bajo la licencia *Creative Commons 4.0* Atribución-No Comercial (CC BY-NC 4.0 Internacional), que permite a terceros utilizar lo publicado siempre que mencionen la autoría del trabajo y a la primera publicación en esta revista.