

Ocotillo flowers as food resource for the mule deer during the dry season

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The plant locally known as *ocotillo*, *Fouquieria splendens* (Fouquieriaceae) is a shrub distributed in arid zones of Mexico and southwestern United States. In Mapimí Biosphere Reserve, Durango, it has not leaves for most of the year; these emerge after the first rain. Inflorescences emerge in March, being bright red and lasting only a month. These inflorescences are highly sought after by animals, including insects, birds and the mule deer (*Odocoileus hemionus*). The objectives of this study were: 1) quantify the inflorescences produced by each plant (during March), 2) estimate inflorescence availability for mule deer, and 3) quantify its contribution in biomass (fresh weight) and nutrient content. This will contribute to understand why deer consume these flowers in the dry season. In March 2012 a field sampling was carried out in the Mapimí Biosphere Reserve, to measure the characteristics of each individual plant, quantify the number of inflorescences produced, the number available for mule deer, and the nutrients they contribute. The nearest-neighbor method was used, measuring 30 ocotillo individuals in nine sites. Inflorescences were collected from different plants to estimate fresh weight and determine nutrient content by proximal chemical analysis. A total of 270 ocotillo plants were sampled. There was a positive correlation between plant diameter and number of both branches and inflorescences. An average of 30 inflorescences was observed, and their availability for deer was 42 % (3,306/7,951) of the total. The average weight of 74 inflorescences collected was 74.8 ± 20.4 g; each plant produced up to 3 kg. These contain high levels of protein (12 % dry basis), carbohydrate (67 %), and 3,085.98 kcal/kg of metabolizable energy; 85 % are digestible nutrients. The mule deer selects plants with high nutritional values that are available in critical seasons such as the dry season. To note, ocotillo flowers emerge when there is food shortage (dry season), and are consumed by deer. A positive correlation was found between number of branches, plant diameter and total number of inflorescences (and its availability). Ocotillo flowers represent an important nutritional resource for deer, because inflorescences have high protein and sugar levels, in addition to having digestible nutrients and that each plant produces around 1.5 kg of inflorescences available for deer in the dry season.

El ocotillo *Fouquieria splendens*, (Fouquieriaceae) es un arbusto que se distribuye en las zonas áridas de México, y del suroeste de Estados Unidos. En la Reserva de la Biosfera de Mapimí, la mayor parte del año no tienen hojas y éstas brotan con las primeras lluvias. Estas inflorescencias de color rojo brillante, son muy apetecidas y son recurso alimenticio en la temporada seca para muchos animales, como insectos, aves, incluyendo el venado bura (*Odocoileus hemionus*). Los objetivos del estudio fueron: 1) cuantificar las inflorescencias que produce cada planta (durante el mes de marzo), 2) cuántas de éstas están disponibles para el venado bura, y 3) y cuantificar la contribución en biomasa (peso fresco) y su contenido de nutrientes. En marzo de 2012 se hizo un muestreo en la Reserva de la Biosfera de Mapimí, para cuantificar las inflorescencias que produce cada planta, cuántas están disponibles para el bura, y que nutrientes podrían estar aportando. Se usó el método del vecino más cercano, midiendo 30 individuos de ocotillo, en nueve sitios. Se colectaron inflorescencias de distintas plantas para determinar el contenido de nutrientes mediante un análisis químico proximal. Se midieron siete variables estructurales de 270 ocotillos. Se encontró una correlación positiva entre la altura y el diámetro de la planta y el número total de inflorescencias. En promedio cada ocotillo tuvo 30 inflorescencias y la disponibilidad para los venados fue del 42 % (3,306/7,951). El promedio de peso de 74 inflorescencias colectadas fue de 74.8 ± 20.4 g, produciendo arriba de 3 kg por planta. Se encontró que el 85 % de los nutrientes son digestibles, entre ellos 12 % de proteína (en base seca), carbohidratos (67 %), y 3,085.98 kcal/kg de energía metabolizable. Considerando la disponibilidad de recursos en temporadas críticas como la temporada seca, el ocotillo es una especie de importancia principalmente por las inflorescencias que brotan en esta temporada. Las variables estructurales de la planta como el número de ramas y los diámetros de las plantas se relacionan positivamente con el número y la disponibilidad de inflorescencias. La disponibilidad promedio de 1.5 kg de inflorescencias por planta, tienen alto valor proteico, energético y de digestibilidad que es aprovechado por diferentes especies, como el venado bura, y es un recurso importante para este herbívoro durante la temporada seca.

Key words: Chihuahuan Desert; dry season; inflorescences; Mapimí Biosphere Reserve; nutritive value.

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Introduction

The plant locally known as *ocotillo* (*Fouquieria splendens*; Fouquieriaceae) is a shrub endemic to arid regions of southwestern United States and northern Mexico (from northern Baja California, Sonora, Chihuahua, Coahuila and Durango; [Walkowiak et al. 1990](#); [Zamudio 1995](#)); it reaches a height of 2 to 6 m and shows simple thorny branches from the base. It has no leaves for most of the year; these emerge sud-

denly after the first rain (March) ([Zamudio 1995](#)). Inflorescences are terminal ([Reyes-Carmona and García-Gil 1982](#); [Bowers 2006](#)) and emerge simultaneously in all plants in early spring (March) and last a little more than a month. Some studies have determined that plant size is positively related with the number of inflorescences ([Díaz et al. 2015](#)), although not necessarily with a larger number of flowers ([Bowers 2006](#)). The bright red flowers are small (2.5 cm,

Reyes-Carmona and García-Gil 1982; Bowers 2006) and, due to their tubular shape, are visited by insects and birds, in addition to being consumed by some birds (*i. e.*, *Icterus* sp.) and mammals (*i. e.*, *Odocoileus hemionus*).

Since ocotillo is a food resource for many animals in the dry season, including the mule deer (*O. hemionus*), the inflorescences produced in each plant during March were quantified, as well as the inflorescences potentially available for *O. hemionus*. Since the mule deer is a highly selective herbivore browser (Short 1981), biomass availability (fresh weight) and nutrient content of *F. splendens* inflorescences were also estimated.

Materials and Methods

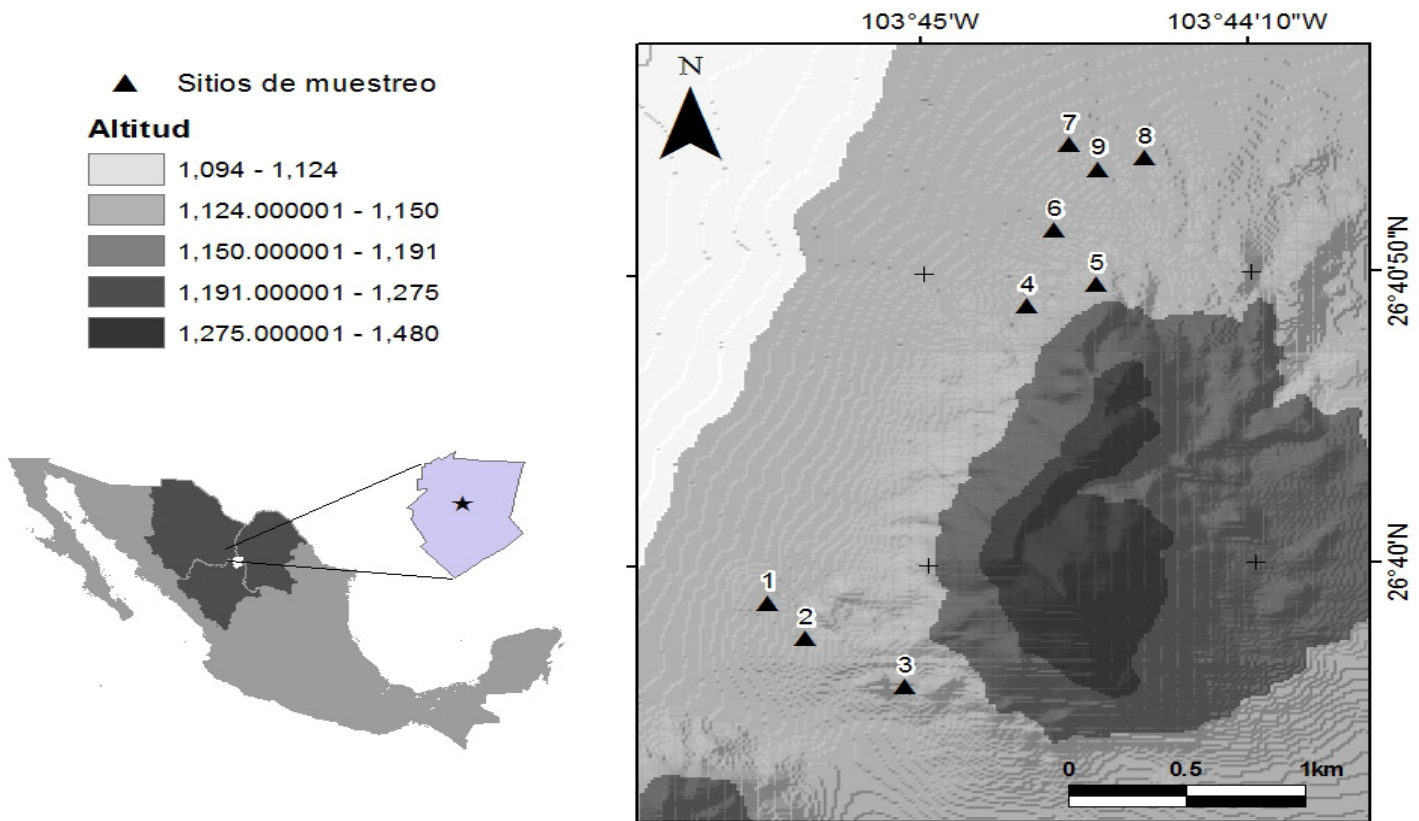
The work was carried out in March 2012 in the foothills and surroundings of Cerro San Ignacio, Mapimi Biosphere Reserve (-103° 45' and -103° 43' W, 26° 40' and 26° 39' N). The local climate is dry and semi-warm (mean annual temperature = 20.8 °C) with summer rainfall (mean annual precipitation = 264 mm). The highest abundance of *F. splendens* occurs in xerophilous scrubland (CONANP 2006). The sampling of ocotillo plants was carried out using the nearest-neighbor method (Clark and Evans 1954). First, an individual was chosen at random, following with the nearest individual of the same species, and so on until 30 individuals were measured. Nine replicas of the sampling were conducted on the foothills of Cerro San Ignacio (Figure 1). The following variables were measured from each plant: 1) distance to the nearest individual, that indicates the species density, 2) shrub height, 3) number of branches, 4) largest

diameter, 5) smallest diameter, 6) total number of inflorescences, and 7) number of inflorescences available for the deer (to a maximum height of 1.80 m, considering the height reached by an adult animal standing on its hind legs (see Figure 2). Inflorescences were collected from other ocotillo plants selected at random to estimate the average fresh weight, which was multiplied by the total number of inflorescences estimated in the first sampling. In addition, the number of available inflorescences were counted to estimate total productivity, and from the inflorescences collected the nutrient content was determined through proximal chemical analyses in the laboratory of Food Chemical Analysis at the College of Veterinary Medicine and Animal Sciences, UNAM.

The measures of central tendency (mean and standard deviation) were obtained for each of the seven variables. To determine which variables affect the number of inflorescences and their productivity, a Pearson correlation matrix was elaborated. All analyzes were performed with the program PAST (Hammer *et al.* 2009). The significance level considered was 0.05.

Results

The seven structural variables were measured in 270 ocotillo plants (30 plants with nine replicates each). The average plant height for the nine replicates was 2.49 m (\pm 0.17) and the smallest diameter was 2.34 m (\pm 0.24). The number of inflorescences per individual plant was 29.45 (\pm 8.23) and the number of inflorescences available at 1.8 m height was 12.24 (\pm 3.08) per plant. The availability of inflorescences



for the mule deer is 41.57 % (3.306) of the total for 270 plants ($n = 7951$).

The number of branches per plant is positively correlated with the number of inflorescences available ($P = 0.007$) and total inflorescences ($P = 0.0119$); also, the available inflorescences are correlated with the largest diameter ($P = 0.004$) and the smallest diameter ($P = 0.001$); and the total inflorescences with the available inflorescences ($P = 0.0004$; Table 1).

The average inflorescence fresh weight was 74.8 g (± 20.5) and the proximal chemical analysis shows that the digestible nutrients account for 85.4 % dry basis, with a metabolizable energy of 3,085.98 kcal/kg; 11.5 % crude protein and 66.9 % carbohydrate (Table 2).

deer in the same area (RBM), protein and lipid levels are 4.0 % and 10.0 %, respectively, in *Euphorbia antisiphilitica* (candelilla); *Jatropha dioica* (sangre de drago) supplies 8.8 % protein and 11.0 % lipids; *Opuntia rastrera* (prickly pear), 4.4 % protein and 5.0 % lipids; *Agave asperrima* (agave), 9.0 % protein and 5.0 % lipids (Cossío Bayugar 2014). If we take into account that the deer requires at least 7.0 % crude protein to survive, 9.5 % to attain moderate growth and 14.0 to 20.0 % for an optimum development (Halls 1984; Brown 1994; Miller and Marchinton 1995; Villarreal 2000), ocotillo shows values of protein and other nutrients that can contribute significantly to the diet of the mule deer in critical times. Although the number of inflorescences consumed and its proportion relative to the total diet of the mule deer in the dry season remain unknown, ocotillo inflorescences

Table 1. Linear correlation matrix for the seven variables measured in *Fouquieria splendens*. Below the diagonal are the correlation coefficient; above, the significance.

	No. Branches	Height (m)	Largest diameter	Smallest diameter	Available inflorescences	Total inflorescences
No. Branches	-	0.169	0.059	0.005	0.007	0.0119
Height (m)	0.501	-	0.264	0.224	0.234	0.2560
Largest diameter	0.649	0.417	-	0.001	0.004	0.0004
Smallest diameter	0.836	0.450	0.946	-	0.001	7.77E-05
Available inflorescences	0.819	0.442	0.841	0.894	-	0.0004
Total inflorescences	0.786	0.423	0.922	0.952	0.921	-

Discussion and Conclusions

The structural variables of the plant, such as the number of branches and the diameter, determined the number of inflorescences in ocotillo, unlike the work of Diaz et al. (2015), who point out that plant size is positively related to the number of inflorescences. The results of this study show that ocotillo flowers are readily available for the mule deer in the critical dry season, with around 1.5 kg of available inflorescences per plant, which are characterized by high protein, energy and digestibility. However, the productivity of inflorescences varies spatially due to plant density (depends on the distance between individuals), which varied between sites more than individual productivity.

The mule deer is a highly selective browser, so that plants with high nutritional value are very important, considering their availability, as ocotillo inflorescences (Short 1981) in this case. Compared to other plants foraged by the mule

can be considered as an important food resource for its nutrient concentration relative to other plants, and also for its high availability in the dry season precisely.

Table 2. Percentage nutrients and energy (dry and wet basis) by Proximal Chemical Analysis of ocotillo inflorescences.

	Wet basis (%)	Dry Basis (%)
Dry matter	65.55	100.00
Moisture	34.45	0
Crude protein	7.51	11.46
Lipids	3.55	5.41
Ash content	3.31	5.05
Crude fiber	7.30	11.13
Nitrogen-free extract	43.88	66.94
Total digestible nutrients	55.96	85.37
Digestible energy (kcal/kg)	2,467.16	3,763.79
Metabolizable energy (kcal/kg)	2,022.86	3,085.98



Figure 2. Upper, ocotillo flower. Lower, mule deer feeding on ocotillo flowers.

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