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Feeding Preferences of Domestic and Wild Ungulates for Forage Trees in the Dry Tropics

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Abstract: Silvopastoralism based on livestock feeding on forage trees is becoming a sustainable alternative to traditional grazing on the open pastures of dry tropical Central America. Four autochthonous trees, *Acacia pennatula*, *Enterolobium cyclocarpum*, *Gliricidia sepium* and *Guazuma ulmifolia*, and one exotic (*Moringa oleifera*) tree are the preferred species for these silvopastoral systems. Little is known, however, about the feeding preferences of cattle, sheep and goats for such fodder trees and whether wild ungulates (white-tailed deer, *Odocoileus virginianus*) feed on these plants. In this work, we conducted several multiple-choice feeding preference tests (cafeteria test) to compare the best choice to feed cattle, sheep, goats and white-tailed deer in these farming systems. Although all ruminant species included the four autochthonous trees and the exotic *M. oleifera* in their diets, *G. ulmifolia* was the preferred forage tree by far. The preference for the rest of the trees varied among our ruminant species. When *M. oleifera* was added to the cafeteria test, it was well accepted by white-tailed deer but little appreciated by their domestic counterparts. The use of these forage trees for livestock feeding is thus interesting not only for sustainable animal production but also to support wild herbivores in the dry tropics of Central America.

Keywords: silvopastoralism; foraging behaviour; *Acacia pennatula*; *Enterolobium cyclocarpum*; *Gliricidia sepium*; *Guazuma ulmifolia*; *Moringa oleifera*

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1. Introduction

Silvopastoralism is globally becoming a good alternative to traditional extensive production based on herbaceous pastures [1,2]. This farming modality, based on livestock feeding on multiple vegetation layers including trees, is gaining momentum in dry tropical environments where bi-seasonality causes food restrictions for half a year [3]. Forage trees are considered "protein banks" [4] because of the high protein contents of their shoots [5]. These plants are used to direct browsing or to create hedgerows that are recurrently pruned by farmers to maintain active growth of leaves and shoots to help livestock overcome periods of food scarcity [6]. The fast increase in areas of forest cleared or burned to make way for crops for livestock is one of the main causes of deforestation in the tropics [7]. Silvopastoral farming based on forage trees would contribute to the restoration of ranching lands [8]. However, little is known about the feeding preferences of livestock for these fodder trees [9]. This information is crucial for designing new silvopastoral systems but in particular when farming is based on mixed herds in rotation or during simultaneous grazing (i.e., different livestock species grazing at the same place and time) [10]. When domestic ruminants have the same feeding preferences, farming may result in competition for the same resource, increasing feeding time variation [11] and decreasing production [12]. However, when livestock species have contrasted feeding preferences, there is a boosted food resource exploitation and more sustainable farming [13]. These silvopastoral systems also provide food and shelter for native wildlife [14], and thus, understanding food resource partitioning between livestock and free-ranging wildlife would contribute to nature protection.

In Central America, *Acacia pennatula* ("carbón"), *Enterolobium cyclocarpum* ("guanacaste"), *Gliricidia sepium* ("madero negro") and *Guazuma ulmifolia* ("guácimo") are the main native tree species used for such silvopastoral purposes [15,16]. *Moringa oleifera* ("marango"), originally from northwest India, is also common in the region, where it is used for living fences to delimit paddocks and due to its nutritional properties, great adaptability, rapid growth and resistance to drought [17]. In fact, this fodder tree has been suggested as a key species to mitigate the effects of climate change on livestock production in the dry tropics worldwide [18]. Whether or not *M. oleifera* trees are influencing the feeding preferences of domestic and wild ungulates for native species remains unknown, and consequently, its use by domestic and wild ruminants.

For more than half a century, cattle and small ruminants (sheep and goats) have been the main extensive livestock of Central America [19]. White-tailed deer (*Odocoelius virginianus truei*) are also a common dweller in these silvopastoral systems, but in particular during the dry season when annual plants are scarce [20]. There is no information, however, about diet overlap between livestock and white-tailed deer in the dry tropics of Central America [21].

The objective of this work was to determine the preferences of cattle, sheep, goats and white-tailed deer for the main forage tree species of the Central American dry tropics. We also studied the effect of including *M. oleifera* in the feed rations on the feeding preferences of our ruminant species. The aim was to detect possible variations in preference for each tree species, specifically due to the anatomical, physiological and behavioural differences in the four ruminant species. The results obtained here will be of great interest for the sustainability of silvopastoral systems and their native fauna in Central America.

2. Materials and Methods

2.1. Study Area

The study was carried out at the Experimental Station "El Limón", of the Universidad Nacional Autónoma de Nicaragua, in Managua, Nicaragua (13°05′31″ N, 86°21′14″ W). This facility is located on the Pacific side of the country at 890 m.a.s.l., with an average annual temperature of 22.3 °C and annual precipitation of 804 mm. The main raining season ranges from May to October. The soil is an acidic (pH: 5.9), clay-loam type with abundant soft rocks and 5.4% organic matter.

2.2. Forage Tree Species

This study's autochthonous forage tree species are *Acacia pennatula*, *Enterolobium cyclocarpum*, *Gliricidia sepium* and *Guazuma ulmifolia*. All of them have great livestock interest for their resilience to browsing and their high nutritive value [22]. In addition, the exotic *Moringa oleifera* was also studied. This tree was introduced in Nicaragua for ornamental purposes back in the 1920s [23] and, as previously mentioned, is currently used for living fences in paddocks. For each tree species, two kilos of mixed fresh foliage from three individuals were collected by hand before starting the trial and stored in plastic bags.

2.3. Animal Species

For our feeding experiments, we used three domestic (cows *Bos taurus*, goats *Capra hircus*, and sheep *Ovis aries*) and one wild (white-tailed deer) ruminant species. Herds of cows and flocks of goats, sheep and white-tailed deer were kept in captivity for research purposes in the Limon station. The herd of cattle was made up of eight brown-Swiss × Brahman crossbred cows, 5–6 years old, lactating in cow–calf system, with a live weight of 382 ± 5 kg. The flock of sheep comprised 17 1–2 years old Pelibuey ewes of 27 ± 1 kg live weight. The flock of goats consisted of 14 8-year-old Anglo-Nubian goats of 49 ± 4 kg live weight.

The selected livestock was the most spread in the study area and completely adapted to local vegetation. Only prime-age or adult animals were used for our trials. Sheep, for example, ranged between 1–2 years old. Age selection for the rest of the breeds was opportunistic but always with adult individuals selected. The herd of nine white-tailed deer included individuals of different sex and age as occurs under free grazing conditions. We allowed animals to feed on the target species for a 5-day adaptation period to avoid biases during our feeding trial [24]. To detect the effect of a new forage species on the feeding behaviour, Moringa leaves were offered directly and without an adaptation period. Animals were kept under veterinary examination during the trials.

2.4. Feeding Trails

Our experiment was based on a set of multiple-choice feeding tests (cafeteria tests, hereafter) [25]. In brief, animals were placed in 3 × 4 m individual boxes to be observed individually. Four cows, six sheep and six goats, different in each season, were observed during the trial. For deer, the herd was kept in a 1052 m^2 enclosure without pasture. The plant material consisted of leaves and stems of less than 0.5 cm in diameter, daily collected from the natural forest of the biological station. Plants were distributed in individual feeders easy accessible to animals.

We conducted two types of experiments, one for comparing the feeding preferences of domestic and native ruminants for the native trees and the other to explore the effect of the Moringa tree on the preferences for the native trees; in other words, we fed animals for seven consecutive days with the native species and then added Moringa for seven additional days. These experiments were set up in the dry and wet seasons and lasted 14 consecutive days. Each individual had 15 min for the cafeteria test once a day; food was offered in the morning, from 8:00 to 10:00 am. Regarding rations, we offered 500 g of fresh forage to cattle, 100 g for sheep and goats and 200 g for the flock of white-tailed deer. The amount of forage and the time of feeding were adjusted during the adaptation period. Forages were randomly distributed to avoid biases. After the cafeteria test, animals had free access to pastures of *Paspalum notatum*, *Cynodon plectostachyus*, and *Hyparrhenia rufa* in greenness period and water ad libitum. After testing, the flock of white-tailed deer had also free access to a specific commercial balanced fodder with the following composition: 91.74% dry matter, 14% crude protein, 25% neutral detergent fibre, 9.82% acid detergent fibre, 2.41% acid detergent lignin and 9% minerals.

2.5. Bite-Count Procedure

Bite count is a direct measurement with a long tradition in foraging behaviour research [26,27]. This method has been chosen for its ease of application in the field and because it does not require the estimation of the dry weight that is applied in the determination of preferences based on the difference between intake and rejection. Preferred species receive more bites than rejected items. The observer remained alongside the focal individual recording the number of bites by the offered plants. A bite was identified by seeing the animal removing a bite of forage. Four observers were trained in bite counting until interobserver variability disappeared. Each observer followed only one individual at a time. Total bite counts per individual over meal duration (15 min) were computed and used as the response variable for our statistical analyses.

2.6. Statistical Analysis

Since our bite counts were zero-inflated and over-dispersed, we used a zero-inflated Negative Binomial Generalized Linear Mixed Model (ZbGLMM) approach using the "glmmTMB" 1.1.3 version package [28] in R statistical software [29]. To avoid model overparameterization, in both the count and zero components, the fixed effect terms were the tree species, the season, the ruminant species, and the tree species × season and the tree species × ruminant species interactions. Additionally, the random effect terms were the animal identity, the feeding days, and the animal identity nested within season. Nonsignificant terms were removed using a stepwise model selection based on the Akaike Information Criterion (AIC). Multiple comparisons were conducted using the Tukey test, and the effect sizes were significant at $\alpha = 0.05$.

2.7. Chemical Composition and Nutritive Value

The chemical components of forages are considered one of the major determinants of diet preference [30,31]. For this reason, the chemical composition and nutritive value of the foliage of the five tree species considered was obtained from an exhaustive literature review. The Internet network search engines used were Isi Web of Knowledge and Google Scholar. In them, the scientific names of each species were crossed with the following terms: chemical composition, crude protein, detergent acid fibre, detergent neutral fibre, detergent acid lignin, organic matter digestibility, total phenols, condensed tannins and energy content.

3. Results

Consumption, in terms of bite counting, of the four native fodder trees by ruminant species is summarised in Tables 1 and 2.

Table 1. Mean, minimum and maximum values of bite count in four native tree species consumed by domestic (goats, sheep and cows) and wild (white-tailed deer, *Odocoileus virginianus*) ruminants during a 14 day cafeteria test. Data in brackets are confidence intervals at 95%.

Tree Species	Goats	Sheep	Cows	White-Tailed Deer
G. ulmifolia	21.3_{a}^{1} (17.3–26.2)	18.1_{a}^{1} (14.7–22.2)	12.4_{a}^{2} (9.9–15.4)	$18.6_{a}^{1,2}$ (14.5–23.9)
A. pennatula	16.3_{b}^{1} (13.2–20.2)	17.3_{ab}^{1} (14.1–21.3)	11.0_{a}^{2} (8.8–13.8)	6.2_{b}^{3} (4.5–8.6)
E. cyclocarpum	14.1_{b}^{1} (11.3–17.5)	15.9_{ab}^{1} (12.9–19.6)	5.1_{b}^{2} (3.4–7.5)	6.6_{b}^{2} (4.8–9.1)
G. sepium	14.4_{b}^{1} (11.6–17.9)	15.3_{b}^{1} (12.4–18.9)	7.1_{b}^{2} (5.5–9.3)	16.7_{a}^{1} (13.2–21.2)

Different subscript letters in the same column indicate significant differences between forage trees. Different superscript numbers in the same row indicate significant differences between animal species.

Table 2. Mean values of bite count in four native and one exotic tree species consumed by domestic (goats, sheep and cows) and wild (white-tailed deer, *Odocoileus virginianus*) ruminants during a 14 day cafeteria test. In this trial, *Moringa oleifera*, an exotic tree from India, was added to the multiple-choice feeding test. Data in brackets are confidence intervals at 95%.

Tree Species	Goats	Sheep	Cows	White-Tailed Deer
G. ulmifolia	20.9_{a}^{1} (18.7–23.4)	17.7_{a}^{1} (15.7–19.8)	11.6_{a}^{2} (9.8–13.6)	12.1_{ab}^{2} (9.7–15.1)
A. pennatula	15.3_{b}^{1} (13.5–17.2)	$11.5_{b}^{2,3}$ (10.1–13.1)	$12.5_{a}^{1,2}$ (10.7–14.7)	8.3_{b}^{3} (6.6–10.6)
E. cyclocarpum	13.1_{bc}^{1} (11.5–14.8)	11.6_{b}^{1} (10.2–13.3)	4.2_{b}^{2} (2.3–7.6)	14.1_{a}^{1} (11.5–17.2)
G. sepium	14.4_{bc}^{1} (12.7–16.4)	12.7_{b}^{1} (11.2–14.4)	7.2_{b}^{2} (5.8–9.0)	12.6_{a}^{1} (10.3–15.4)
M. oleifera	11.7_{c}^{1} (10.1–13.5)	8.9_{c}^{2} (7.7–10.3)	6.6_{b}^{2} (5.1–8.4)	15.1_{a}^{1} (12.3–18.5)

Different subscript letters in the same column indicate significant differences between forage trees. Different superscript numbers in the same row indicate significant differences between animal species.

Our ZbGLMM revealed that our bite counting depended on the ruminant species and the plant offered (Table 3). In general terms, plant consumption varied among our four native tree species, with *A. pennatula* the preferred tree, followed by *G. ulmifolia*, *G. sepium* and finally *E. cyclocarpum* (Table 1). The most consumed species was *G. ulmifolia*, but the rest of the preferences varied between animals. Goats gave more bites to this species and less but similar numbers to the other three species. Sheep also gave a higher number of bites to *G. ulmifolia*, but the fewest numbers were given to *G. sepium.* Cows ate more *G. ulmifolia* and *A. pennatula* and much less *E. cyclocarpum* and *G. sepium.* Finally, white-tailed deer browsed more in *G. sepium* and *G. ulmifolia* than in *A. pennatula* and *E. cyclocarpum*.

Table 3. Estimates, overdispersion parameter, log-likelihood and AIC from the zero-altered Negative Binomial Generalized Linear Mixed Model. Significant effects are shown in bold. (Coeff. coefficients; SE, standard errors; AIC, Akaike Information Criterion). *Acacia pennulata* has been considered the reference category in the zero-inflated ZbGLMM. *Enterolobium cyclocarpum (E. cyclocarpum)*, *Gliricidia sepium* (*G. sepium*), *Guazuma ulmifolia* (*G. ulmifolia*), *Moringa oleifera* (*M. oleifera*); deer is *Odocoileus virginianus*.

Four Tree Species			Five Tree Species		
Variables	**Coeff.**	**SE**	**Variables**	**Coeff.**	**SE**
Count model Fixed effects			***Count model Fixed effects***		
Intercept	**2.884**	**0.116**	Intercept	**2.775**	**0.065**
G. ulmifolia	**0.265**	**0.057**	*G. ulmifolia*	**0.315**	**0.059**
E. cyclocarpum	**−0.150**	**0.065**	*E. cyclocarpum*	**−0.156**	**0.067**
G. sepium	−0.124	0.064	*G. sepium*	−0.058	0.066
Dry season	**−0.183**	**0.092**	*M. oleifera*	**−0.267**	**0.076**
Sheep	0.058	0.142	Dry season	**−0.099**	**0.042**
Cow	**−0.395**	**0.150**	Sheep	**−0.283**	**0.089**
Deer	**−0.967**	**0.192**	Cow	**−0.197**	**0.099**
G. ulmifolia:Sheep	**−0.221**	**0.083**	Deer	**−0.605**	**0.136**
E. cyclocarpum:Sheep	0.067	0.090	*G. ulmifolia*:Sheep	0.113	0.090
G. sepium:Sheep	0.000	0.089	*E. cyclocarpum*:Sheep	0.166	0.100
G. ulmifolia:Cow	−0.149	0.090	*G. sepium*:Sheep	0.157	0.098
E. cyclocarpum:Cow	**−0.626**	**0.191**	*M. oleifera*:Sheep	0.012	0.112
G. sepium:Cow	**−0.308**	**0.118**	*G. ulmifolia*:Cow	**−0.396**	**0.106**
G. ulmifolia:Deer	**0.835**	**0.164**	*E. cyclocarpum*:Cow	**−0.931**	**0.310**
E. cyclocarpum:Deer	0.216	0.196	*G. sepium*: Cow	**−0.496**	**0.133**
G. sepium:Deer	**1.114**	**0.163**	*M. oleifera*:Cow	**−0.382**	**0.149**
			G. ulmifolia:Deer	0.059	0.156
			E. cyclocarpum: Deer	**0.678**	**0.154**
			G. sepium: Deer	**0.473**	**0.152**
			M. oleifera: Deer	**0.860**	**0.157**
Random effects			***Random effects***		
Animal identity	0.013		Animal identity	0.018	
Feeding days	0.011		Feeding days	0.002	
Animal identity nested within season	0.014		Animal identity nested within season	6.7×10^{-10}	
Zero-inflated model Fixed effects			***Zero-inflated model Fixed effects***		
Intercept	**−3.737**	**0.295**	Intercept	**−3.449**	**0.263**
G. ulmifolia	0.137	0.234	*G. ulmifolia*	0.060	0.245
E. cyclocarpum	**1.971**	**0.240**	*E. cyclocarpum*	**1.405**	**0.239**
G. sepium	**0.875**	**0.231**	*G. sepium*	**0.593**	**0.239**
Sheep	**−2.452**	**0.747**	*M. oleifera*	**1.499**	**0.239**
Cow	**2.012**	**0.265**	Sheep	−0.383	0.296
Deer	**3.871**	**0.274**	Cow	**1.864**	**0.236**
			Deer	**3.501**	**0.228**
Overdispersion parameter	1.66		***Overdispersion parameter***	1.71	
Log-likelihood	−3722.7		***Log-likelihood***	−4124.4	

When the exotic tree was added to the four native species, the probability of selection was modified accordingly (*A. pennatula* = *G. ulmifolia* > *G. sepium* > *E. cyclocarpum* > *M. oleifera*, $p < 0.05$). We observed the same pattern in the probability of browsing among animal species and the number of bites during both seasons when *M. oleifera* was offered. Table 2 shows the consumption values after the introduction of the exotic tree, *M. oleifera*, in the multiple-choice test. Goats and sheep continued to eat more bites overall. Goats maintained the highest *G. ulmifolia* consumption among the other native species, and *M. oleifera* was the least consumed. In this phase of the trial, sheep showed a pattern similar to that of goats. Cows also maintained their consumption pattern, incorporating *M. oleifera* in the group with the least consumed. In the case of white-tailed deer, *M. oleifera* and *E. cyclocarpum* were incorporated into the group of the most consumed species, and *A. pennatula* was less browsed than the rest.

4. Discussion

In this work, we experimentally evaluated the feeding preferences of domestic and wild ruminants for native and exotic fodder trees of the dry tropics of Central America. All of the ruminants consumed the four species of native trees to a greater or lesser extent. In addition, all of them incorporated *M. oleifera* into their diets, despite being an exotic species. The fact that none of them were completely rejected is probably due to their high nutritional value. The acceptance of these woody forages would be explained by their high sugar and protein contents and their low concentrations in secondary compounds. This is shown in Table 4, which contains the bibliographic review of the chemical composition of the foliage of the five species considered. All of them show a high CP content, not only above the maintenance threshold 7% of DM, but also above the necessary threshold for animal production (milk or meat) of 13.5% dry matter, as suggested by Van Soest and NRC [32,33].

Table 4. Chemical composition of fodder trees. CP: crude protein (%), NDF: neutral detergent fibre (%), ADF: acid detergent fibre (%), ADL: acid detergent lignin (%), OMD: organic matter digestibility (%), TP: total phenols (%), CT: condensed tannins (%), Sap: saponins (%), EC: energy content (Mcal/KgDM).

Species	CP	NDF	ADF	ADL	OMD	TP	CT	Sap	EC	Source
A. pennatula	20.1	53.1	33.3	12.3						[34]
A. pennatula	11.5–14.2	34.2–35.2	20.7–24.4	11.6–15.4	28.6–34.4	8.2–9.4	3.1–4.3		1.1–1.3	[35]
A. pennatula	19.6	30.4	17.5		49.6	7.6			3.7	[36]
A. pennatula	23.4	25.2				6.3–18.3	5.5–8.1			[37]
A. pennatula	13.6	32.7	11.3	11.3		11.3	2.3			[38]
E. cyclocarpum	20	70.2	24.6					2.8		[39]
E. cyclocarpum	19.7	49.5	35.3	30.8		1.8		1.9	2.3	[40]
E. cyclocarpum	15.7	50.4	30.7			7.4	3.8			[41]
E. cyclocarpum	23.1	58.9	48.6		66–69					[42]
E. cyclocarpum	19.4	36.5	25.5	4.7					2.9	[43]
E. cyclocarpum	18.6				51.4			present	1.8	[44]
E. cyclocarpum	21.6	36.5	33.4	20.7				4.4		[45]
G. sepium	16.3	48	32	9.8	61.3				2.3	[46]
G. sepium	22.1	40.1	20.4	10.2						[36]
G. sepium	17	57.5	45.2			0.6	4.6	1.7	4.4	[47]
G. sepium	20.8	32.7	21.1		69.9	0.3				[41]
G. sepium	23.8	42.8	25				low	moderate		[48]
G. sepium	27.4	39.4			75.5	2	0.4		4.1	[49]
G. ulmifolia	15.1	55	38		60				4.7	[50]
G. ulmifolia	16.5			16.9	56		0.01		3.6	[51]
G. ulmifolia	15.5	49.6	25.9	10.7	59					[52]
G. ulmifolia	13.8	45.1	28.9	11.2		moderate				[53]
G. ulmifolia	22.2	37.7			80.7	1.7	0.1		3.8	[49]
M. oleifera	28.9	16.7	12.1	6.5					4	[54]
M. oleifera	25.1	21.9	11.4	1.8	74				4.3	[23]
M. oleifera	22.2			3.9				6.6	3.6	[55]
M. oleifera	30.3	11.4	8.5	1.8		2	0.3			[56]
M. oleifera	20.2	48.3	35.4	9.3						[57]
M. oleifera	26.6	42.5			90.9	3.9	1		4.3	[49]

Preference is positively related to palatability [58], and palatability is the relationship between the food's traits and animal post ingestive feedback [59]. Taking this into account, it is worth noting the preference for *G. ulmifolia* by the four herbivore species. It could be explained because *G. ulmifolia* presents a high in vitro digestibility similar to that of *Medicago sativa* [60], high energy value, low tannin content and lack of saponins (Table 4). Differences between animal preferences appeared in the rest of the species and could be related to the interaction between animal type and the chemical composition of the foliage. In that sense, cows and sheep are considered grazers, which means they are not very selective eaters [61]. Contrarily, goats are concentrate selectors that selectively browse the most palatable and nutritious plant species. The same goes for the subspecies of white-tailed deer from Nicaragua (*O.v. truei*), typical browsers of forest environments [62]. In addition, goats and white-tailed deer possess several distinct detoxification pathways to prevent toxicity of plant secondary compounds [63,64], and this could explain a greater preference for the species that appear more rejected by the cows. On the other hand, the other three native trees belong to the Fabaceae family, generally rich in protein but also secondary antinutritional compounds (Table 4). *Acacia pennatula* is rich in terpenes, coumarins and flavones [65]. Leaves of *E. cyclocarpum* contained saponins and tannins and high lignin content values. *G. sepium* is generally considered to be one of the most digestible tropical leguminous forages, although it contains moderate amounts of saponins and coumarins [32] that could provide a bitter taste. In relation to *M. oleifera*, the leaves contain saponins and, although they contain low values of lignin and considerable amounts of CP, these are mostly insoluble [66]. In addition, Qwele et al. [67] reported a certain amount of polyphenols.

The preference for *Guazuma ulmifolia* among the four animal species allowed us to conclude that competition phenomena could occur if the animals coexist and the resource is limited. This competition could be greater in the case of mixed herds of sheep and goats, as both follow a very similar pattern of preferences. Instead, white-tailed deer show a preference for *G. sepium*, in addition to *G. ulmifolia*, not observed in the other animals, and the same occurs in the case of cows with *A. pennatula*. This means mixed herds of cows with goats or cows with sheep, both with the presence of white-tailed deer, could be a better option in terms of resource partitioning and, consequently, for the sustainability of the ecosystem.

The incorporation of *M. oleifera* did not imply any change in the order of preference among the domestic animals, which incorporated it in the last position. However, its introduction did affect the order of preference of the native white-tailed deer. In this case. *M. oleifera* becomes a preferred species and also increased the consumption of *E. cyclocarpum*. Therefore, it can be concluded that the introduction of an exotic fodder tree could be of interest for animal production, but one has to be prudent if the objective is the sustainable management of domestic livestock in coexistence with wildlife.

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