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Olivares-Pérez, Jaime; Rojas-Hernández, Saúl; Avilés-Nova, Francisca; Camacho-Díaz, Luis M; Cipriano-Salazar, Moises; Jiménez-Guillén, Régulo; Quiroz-Cardozo, Fredy

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USES OF NON-LEGUMINOUS TREES IN SILVOPASTORAL SYSTEMS IN THE SOUTH OF THE STATE OF MEXICO

Usos de los árboles no leguminosos en sistemas silvopastoriles del sur del estado de México

Jaime Olivares-Pérez[1*], Saúl Rojas-Hernández[1], Francisca Avilés-Nova[2], Luis M Camacho-Díaz[1], Moises Cipriano-Salazar[1], Régulo Jiménez-Guillén[3], Fredy Quiroz-Cardozo[1]

[1] Unidad Académica Medicina Veterinaria y Zootecnia, Universidad Autónoma de Guerrero, Carretera Cd. Altamirano - Iguala km 3. Col. Las Querenditas, Pungarabato, Guerrero, Mexico.
[2] Centro Universitario de la Universidad Autonoma del Estado de México-Temascaltepec, Estado de México.
[3] Instituto Nacional de Investigaciones Agrícolas, Forestales y Pecuarias Campo Experimental Iguala, Guerrero, Mexico.
*Corresponding author: saulrh@hotmail.com

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ABSTRACT. The objective was to characterize the livestock production units (LPU) and identify the forage importance, uses, and density of non-leguminous trees in silvopastoral systems in the south of the State of Mexico. Sixty-nine surveys were conducted to ascertain the current use of trees; on transects were evaluated their density, abundance and frequency; the diameter at breast height (DBH) and the height (h) of trees were measured metrically. The most important trees with regard to foraging were *Guazuma ulmifolia* (72.5 %) and *Crescentia alata* (63.8 %). These trees had the highest number of uses at seven and nine, respectively. The density of scattered trees and trees used for living fences was highest for *G. ulmifolia* (4.5 trees ha^{-1} and one tree per 100 linear m) and *C. alata* (7.2 trees ha^{-1} and 0.54 trees per 100 linear m). The DBH for scattered trees was highest for *C. alata* at 44.4 cm, while in the case of living fences it was highest for *Ficus glabrata* at 114.5 cm. We conclude that the outstanding PU accounting uses, foraging preference, and dasometric characteristics are accounted for by *C. alata* and *G. ulmifolia*, which as multiple purpose trees can be integrated in silvopastoral systems in the study area.
Keywords: Uses, foraging preference, dasometric characteristics, trees, density

RESUMEN. El objetivo fue caracterizar las Unidades de Producción Pecuaria (UPP), e identificar la importancia forrajera, usos y la densidad de los árboles no leguminosos en los sistemas silvopastoriles del sur del Estado de México. Se realizaron sesenta y nueve encuestas para conocer el uso de los árboles; en transectos se evaluaron su densidad, abundancia y frecuencia; el diámetro a la altura del pecho (DAP), con la altura (h) del árbol se midieron métricamente. Los árboles con mayor importancia forrajera fueron *Guazuma ulmifolia* (72.5 %) y *Crescentia alata* (63.8 %); estos mismos árboles presentaron el mayor número de usos con siete y nueve, respectivamente. La densidad de árboles dispersos y en las cercas vivas fue mayor para *G. ulmifolia* (4.5 árboles ha^{-1} y un árbol en 100 m lineales) y *C. alata* (7.2 árboles ha^{-1} y 0.54 árboles en 100 m lineales). El DAP en árboles dispersos fue mayor en *C. alata* con 44.4 cm y en árboles en la cerca viva fue en *Ficus glabrata* con 114.5 cm. Se concluye que en las UP los árboles más sobresalientes por sus usos, preferencia forrajeras y características dasométricas fueron *C. alata* y *G. ulmifolia*, y por ser árboles con usos múltiples, pueden ser integrados a los sistemas silvopastoriles en el área de estudio.
Palabras claves: Usos, preferencia forrajera, características dasométricas, árboles, densidad

INTRODUCTION

Given its edaphic, topographic, and climatic characteristics, Mexico is rich in natural resources, mainly sustained by its diversity of tree species (Palma 2006). In some systems the use of trees as a forage resource is limited, even though it can represent a valuable food source for cattle and wild fauna (Olivares-Perez *et al.* 2013, Olivares *et al.* 2013, Rojas-Hernandez *et al.* 2015). A silvopastoral system is characterized by the interaction of trees, shrubs, grasses and pasture with animals and soil in time and space (Guerreiro *et al.* 2015, Olivares-Perez *et al.* 2011). In any silvopastoral system, the aim is to establish multipurpose trees which should be able to adapt to diverse soil and climate conditions (Reis *et al.* 2010, Olivares-Perez *et al.* 2011). Among the required characteristics should be the ability to fix nitrogen, which restores soil fertility, nutrient recycling, sequestering of carbon dioxide, and support of biodiversity (Nair *et al.* 2009, 2010, Lorenz and Lal 2014, McGroddy *et al.* 2015). Nowadays, it is important to reevaluate traditional knowledge and uses of native species, since these are the basis for their integration in silvopastoral systems. This procedure has been developed in several systems where several uses have been reported, such as fuel (firewood), wood, forage, human foodstuffs (flowers and fruits), medicine, industrial (dyes and resins), fences (posts and living fences), and shade for livestock (Olivares-Pérez *et al.* 2011, Leon-Castro *et al.* 2015).

One way to maintain balance in the ecosystem and preserve plant species is to create technological alternatives that help to increase productivity. One such method is to use non-leguminous trees and shrubs, given the diversity of functions that they can have within tropical production systems and their important role in ruminant feeding (Rojas *et al.* 2012, 2013, Olivares *et al.* 2013, Jimenez-Ferrer *et al.* 2015). The objective of the present study was to identify the foraging importance, uses, and density of non-leguminous trees in silvopastoral systems in the southern part of the State of Mexico.

MATERIALS AND METHODS

The study was carried out in the communities of Bejucos of Sanchez Colin and Llano Grande in the municipality of Tejupilco, State of Mexico (18º 45' 30" and 19º 04' 32" north, 99º 59' 07" and 100º 36' 45" west). The climate is tempered subhumid and semi-warm humid with rains in summer, with a mean annual temperature between 15 and 30 °C, an altitude of 1 340 m, and annual precipitation of 1 014 mm. Soil types are regosol (61.76 %), leptosol (22.11 %), cambisol (6.99 %), luvisol (4.22 %), phaeozem (3.34 %) and vertisol (0.7 %) (Prontuario de información geográfica municipal de los Estados Unidos Mexicanos 2009).

Characterization of the production units (PU)

The populations have a census of 83 producers; 69 LPU were characterized, 54 in Bejucos and 15 in Llano Grande. A questionnaire was used in which the following aspects were considered: non-leguminous foraging trees they know, uses and/or benefits they obtain from them, parts consumed by livestock (based on empirical observation by livestock farmers), place and season of consumption, spatial distribution within the LPU (Harvey and Haber 1999, Sosa *et al.* 2004).

Diagnosis of diversity, density, frequency, and relative abundance of tree species

Field measurements were taken in 878 ha, integrating six PU. In each of these, four 1 h transects were outlined to identify trees scattered in the pastures, and four 100 linear m transects were measured to count trees in living fences (Camacho 2000). Through visual verification of the transects we registered the density of scattered species in the paddocks (trees per ha^{-1}) and in the living fences, and relative frequency (Fr), calculated by dividing the number of transects where each species was found by the total number of transects in the sample.

Dasometric diagnosis

The trees identified in the transects were measured dasometrically to determine diameter at breast height (DBH) and height (h). Five adult trees of each identified species were randomly chosen; their height was measured with a Haglöf electronic clinometer (HEC) and DBH was measured with a tape measure 130 cm from the ground (Camacho 2000, Sosa *et al*. 2004). For botanical identification, the common name was registered and branches (stem, leaves, flower and/or fruit) of each species were collected. Identification was performed in the botany laboratory of the Temascaltepec University Center of the Autonomous University of the State of Mexico, with the use of procedures and identification keys described by Pennington and Sarukhan (2005).

Statistical analysis

Relative abundance (Ar) was estimated by dividing the number of individuals of each tree species by the total number of non-leguminous trees present in each sample area (Camacho 2000). The information on uses, density, relative frequency, relative abundance, and variables related to the dasometric measurements of the trees were analyzed through descriptive statistics (Steel and Torrie 1988).

RESULTS

Characteristics of the production units

The size of the 69 LPU (6 356.5 ha) varied from 2 to 500 ha. The PU are characterized as follows: meat production (62.3 %), dual-purpose (34.8 %), and sheep-goats (2.90 %). The inventory of the animals is: 4 273 cows which include beef breeds such as the European Swiss, Brahman, Simmental, Simbrah, Beefmaster and Charolais; 446 goats with production of creole breeds and their crosses with Nubians and Boers; and 187 sheep with a majority of Pelibuey breeds and their crosses with Dorper sires. Some 86 % of them supplement in the dry season. The feeding system in the LPU is undergrazing with use of native grasses in 78.7 % (4 854.4 ha) of the area devoted to livestock and with induced pastures in 21.3 % (1 315.1 ha) of the remaining surface, with predominance of the following grasses: *Andropogon gayanus* (1 256.6 ha), followed by *Cynodon nlemfuensis* (23.5 ha), *Panicum maximun* (23.5 ha), mulato hybrid (*Brachiaria ruziziensis* x *Brachiaria brizantha*) (10 ha), and *Brachiaria brizantha* (1.5 ha). The predominant foraging crops are maize (471 ha) and sorghum (43 ha); 28 % of these crops are silaged and 72 % used as ground hay to supplement animal fodder. The main labor force in the PU is the family (86 %), while over 54 % of the LPU hire temporary laborers and 52 % use permanent contracts.

Knowledge of the use of the trees in the LPU

Producers have ample knowledge of the consumption of tree species by their animals; despite this, only 4 % of them mentioned having harvested foliage or fruits from the trees to feed their confined animals. Although the trees provide foliage and fruits to feed livestock, only 26 % of the LPU plant trees to reforest and 64 % of the producers mentioned that their animals consume foliage and fruits in the dry season during grazing. The uses of trees in the LPU are as shadow (36 % of the surveys highlighted *Ficus glabrata, Spondias purpurea, Crescentia alata, Magifera indica,* and *Guazuma ulmifolia* by its greater crown diameter; as livestock forage (42 % of the surveys highlighted *G. ulmifolia, C. alata, F. glabrata,* and *M. indica*); and as live fences (29 % of surveys listed *G. ulmifolia, C. alata, F. glabrata, Ipomoea murucoides, S. purpurea,* and *Mastichodendron capiri*) (Table 1). Limitations of the trees were singled out as invasive species in 19 % of the surveys, and trees that cause economic problems in 7 % of surveys for *I. murucoides* and *P. guajava* for being species with high dispersal and seed production that require control practices of their density; The 3 % of livestock farmers mentioned that *Licania arborea, Ficus cotinifolia* and *F. glabrata* decreases the growth of pastures under the crown diameter. The distribution system of the trees in the LPU was established as follows: 93 % of the trees in fences, 96 % trees scattered in the grasslands, 19 % fruit trees, 1.4 % trees in living fences, and 55 % shrubbery as part of the original vegetation.

Table 1. Benefits and limitations of trees identified in livestock production units (LPU).

Benefits of trees in the LPU	Trees	(%)**
Shade	*Ficus glabrata, Spondia purpurea, Crescentia alata, Mangifera indica, Guazuma ulmifolia*	36
Livestock fodder	*Guazuma ulmifolia, Crescentia alata, Ficus glabrata, Mangifera indica*	42
Live fences	*Guazuma ulmifolia, Crescentia alata, Ficus glabrata, Ipomoea murucoides, Spondia purpurea, Mastichodendron capiri*	29
	Limitations of trees in the LPU	
Invasive species*	*Ipomoea murucoides, Psidium guajava*	19
Economic problem*	*Ipomoea murucoides, Psidium guajava*	7
Lack of grass growth	*Licania arborea, Ficus cotinifolia, Ficus glabrata*	3

* Trees invasive in terms of high production and seed dispersal; controlling their density causes economic problems, ** Values obtained are based on the opinion of livestock farmers.

Table 2. Frequency with which producers mentioned non-leguminous trees and parts consumed by livestock.

Common name	Scientific name	Frequency	Foliage	Fruit	Flower
			%		
Cuahulote	*Guazuma ulmifolia*	72.5	56.5	66.7	1.4*
Cirián	*Crescentia alata*	63.8	46.4	52.2	50.7
Ceiba	*Ficus glabrata*	36.2	14.5	30.4	0
Mango	*Mangifera indica*	14.5	8.7	14.5	0
Cazaguate	*Ipomoea murucoides*	8.7	2.9	2.9	4.3
Ciruelo	*Spondias purpurea*	5.8	4.3	5.8	0
Capire	*Mastichodendron capiri*	2.9	2.9	2.9	0
Guayabo	*Psidium guajava*	1.4	1.4	1.4	0
Cabrigo	*Ficus cotinifolia*	1.4	1.4	1.4	0
Cacahuananche	*Licania arborea*	1.4	1.4	0	0

*The total is more than 100 % because of multiple responses.

Parts of trees consumed by livestock

The frequency with which the producers mentioned foraging trees and the parts of the trees on which the animals feed allow them. The experience of livestock farmers, it facilitated to select the species with higher foraging potential. *G. ulmifolia* and *C. alata* are the ones that the producers report as having the highest foraging potential. Producers mentioned that the fruits are the morphological component most favored by livestock, which account for 66.7 and 52.2 % of fruits from the aforementioned trees (Table 2).

Uses of trees in production units

Non-leguminous trees, besides being an important source of forage for livestock, have other uses in the LPU. *C. alata* had nine local uses, especially as shade (62.3 %), living fences (49.3 %), and medicine (52.2 %). *G. ulmifolia* had seven uses, most importantly as shade (65.2 %), living fences (52.2 %), and firewood (44.9 %). *P. guajava, F. glabrata,* and *S. purpurea* had six uses. It is important to mention that seven species are used as medicinal plants, particularly *C. alata* and *G. ulmifolia* (Table 3).

Density, frequency, and abundance of non-leguminous foraging trees

Five native species are reported to be the product of natural regeneration, with a population of 291 trees (24 ha) scattered in the grasslands at a mean density of 12.2 trees ha^{-1}. The trees with the highest density were *C. alata* and *G. ulmifolia*, with 7.2 and 4.5 trees per ha^{-1}, respectively (Table 3). The most abundant and frequent species were *C. alata* (59.1 and 83.3 %) and *G. ulmifolia* (36.8 and 83.3 %), respectively. In the fences, we found 46 trees (2 400 m) with a mean density of 1.75 trees. The species with the highest density is *G. ulmifolia*, making

Table 3. Local knowledge of producers on the use of non-leguminous trees in Llano Grande and Bejucos, State of Mexico.

Tree	Le (%)*	Po (%)	So (%)	Ac (%)	Me (%)	Ch (%)	Ar (%)	Or (%)	Ma (%)
C. alata	34.8	21.7	62.3	49.3	52.2	27.5	23.2	1.4	4.3
G. ulmifolia	44.9	17.4	65.2	52.2	14.5	4.3	0.0	1.4	0.0
M. indica	8.7	1.4	14.5	5.8	0.0	14.5	0.0	0.0	0.0
I. murucoides	2.9	0.0	5.8	5.8	1.4	0.0	0.0	0.0	0.0
P. guajava	1.4	1.4	1.4	1.4	1.4	1.4	0.0	0.0	0.0
F. glabrata	5.8	4.3	33.3	21.7	1.4	0.0	1.4	0.0	0.0
M. capiri	0.0	0.0	2.9	2.9	0.0	2.9	0.0	0.0	0.0
F. cotinifolia	1.4	1.4	1.4	1.4	0.0	0.0	0.0	0.0	0.0
S. purpurea	4.3	1.4	5.8	4.3	1.4	4.3	0.0	0.0	0.0
L. arborea	0.0	0.0	1.4	1.4	1.4	0.0	1.4	0.0	0.0

*The total is more than 100 % because of multiple responses. Le: firewood, Po: posts, So: shade, Ac: living fence, Me: medicinal, Ch: human consumption, Ar: artisanal, Or: ornament, Ma: timber.

Table 4. Density, frequency, and abundance of non-leguminous trees scattered in pastures and living fences.

Scientific name	Scattered trees			Trees in living fences		
	Density (1 ha)	Abundance (%)	Frequency (%)	Density 100 m	Abundance (%)	Frequency (%)
C. alata	7.2	59.1	83.3	0.54	30.2	50.0
G. ulmifolia	4.5	36.8	83.3	1.0	58.1	54.2
F. glabrata	0.1	0.7	8.3	0.08	4.7	8.3
F. cotinifolia	0.1	0.7	8.3	0.0	0.0	0.0
S. purpurea	0.3	2.7	29.2	0.13	7.0	8.3

it the most important species in the LPU (Table 4).

Dasometric measurements of non-leguminous trees

In the two silvopastoral systems, scattered trees in pastures and living fences trees, the identified species were *C. alata, G. ulmifolia, C. glabrata, F. cotinifolia,* and *S. purpurea* (Table 5). For the scattered trees, the range of diameter at breast height (DBH) was 30.1 to 44.4 cm, and height was 6.3 to 9.5 m, while for living fence trees it was 28.9 to 117.3 cm DBH and height was 4.9 to 28.0 m (Table 5). The trees that had higher natural regeneration were *C. alata* and *G. ulmifolia* in the silvopastoral system of trees scattered in the grasslands with a DBH minor to 1 cm and a total of 50 plantlets for *C. alata* and 19 plantlets for *G. ulmifolia*, respectively (Figure 1).

DISCUSSION

The results indicate that in most LPU the animals feed on the foliage/fruits of the trees in the field during grazing hours as much as they can, since only 4 % of the producers use a harvest and carry system with the trees. Similar studies report that the number of producers using the foliage and fruits of the trees in a harvest and carry system to feed livestock is limited (Olivares-Perez *et al*. 2011). Zamora *et al*. (2001) report differently that producers collect the foliage and collect and buy the fruits to feed the animals when gramineae lose their nutritious value, making the fruits and dry leaves the main forage source. In Colombia, during the dry season, 83 % of producers depend on foraging trees to feed their livestock, especially those producing pods and/or fruits (Cajas and Sinclair 2001). Therefore, the use of trees as forage is limited to browsing on living fences or trees in the paddock. It is necessary to train producers in the management and preservation of tree resources in their LPU to maximize their use. With regard to the benefits that trees have for the LPU, livestock feeding is of great importance (42 %) (Cajas and Sinclair 2001, Guerreiro *et al*. 2015, Jimenez-Ferrer *et al*. 2015); however, trees also favor the organic carbon entry and increased the nutrient content soil (Nair *et al*. 2009, 2010, Lanna *et al*. 2010, McGroddi *et*

Table 5. Density, frequency, and abundance of non-leguminous trees scattered in pastures and living fences.

Scientific name	Scattered trees		Trees in living fences	
	DBH* (cm)	Height (m)	DBH*	(cm) Height (m)
C. alata	44.4 (±15.0)	8.5 (±2.0)	40.9 (±24.4)	8.9 (±1.5)
G. ulmifolia	30.2 (±13.0)	7.0 (±2.0)	28.9 (±12.2)	8.2 (±2.2)
F. glabrata	33.0 (±11.09	8.5 (±5.7)	117.3 (±3.9)	28.0 (±2.8)
F. cotinifolia	31.7 (±11.8)	9.5 (±2.1)	-	-
S. purpurea	30.1 (±12.3)	6.3 (±3.5)	28.9 (±16.2)	4.9 (±0.06)

*Diameter Breast Height; ± Standard deviation.

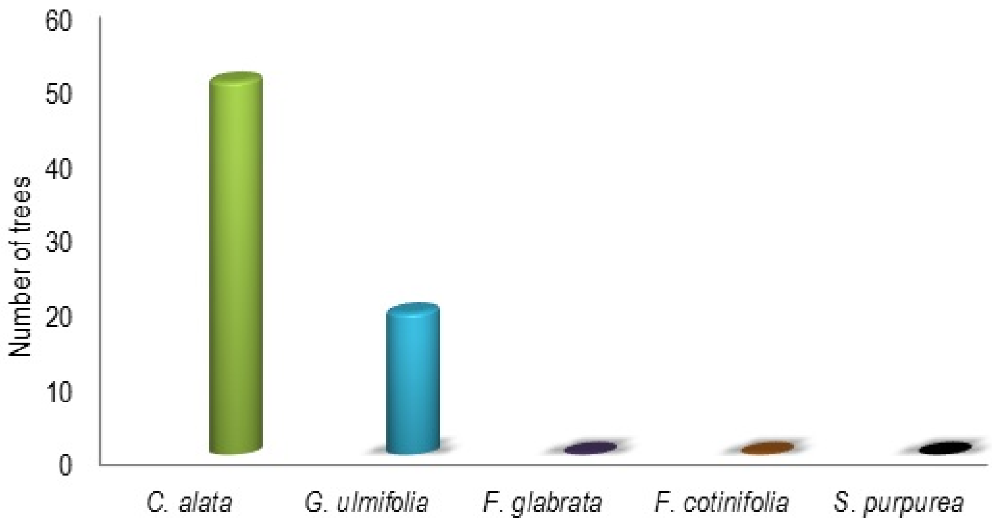

Figure 1. Trees in natural regeneration in disperse systems in pastures (number of plants with <10 cm DBH).

al. 2015). With regard to the limitations of trees in the LPU, the answers of the producers agree with data reported by Harvey and Haber (1999) in that 45 % of the LPU control tree density because they produce too much shade and invasive species are eliminated because of their high capacity to regenerate.

Parts of trees consumed by livestock

The higher foraging potential of *G. ulmifolia* and *C. alata* (Table 2) coincides with studies carried out in Jamaica and Honduras, where producers prefer to use the foliage and fruits of *G. ulmifolia* and *C. alata* with harvest and carry management to feed their livestock (Barrance *et al.* 2003). The foliage of *G. ulmifolia* is consumed during the rainy season; however, during the dry season, when the fruits ripen and dehydrate because of the sun, they fall off and are eaten by the livestock (Olivares-Perez *et al.* 2011). Producer preference for certain species depends on the services and products that the tree offers the LPU, which can be implemented and developed in silvopastoral systems (Olivares-Perez *et al.* 2011). This facilitates the producers becoming participants in the technological development of their LPU (Pinto *et al.* 2005).

Use of trees in the production units

Most of the trees identified have multiple uses and are important components of the natural vegetation in the area, with good adaptation to the local environmental conditions (Table 3). These results coincide with studies performed in other states in the country (Mexico); in Morelos (Solares 2004), Quintana Roo (Sosa *et al.* 2004), Tejeda, Veracruz (Couttolenc *et al.* 2005), Angostillo, Veracruz (Villa *et al.* 2009), Sierra of Tabasco (Grande *et al.* 2010), The Limon, Veracruz (Bautista *et al.* 2011); and in other countries, in Rio Frio, Costa Rica (Villacis *et al.* 2003), in the Caribbean, Colombia (Cajas and Sinclair 2001), in the Pacific, Costa Rica (Harvey and Haber 1999). This shows that the use of trees in different regions is similar; generally speaking, producers prefer to keep trees that offer more products and services to the LPU (Esquivel *et al.* 2011).

Density, frequency, and abundance of non-leguminous trees

Although the study was centered around non-leguminous trees (Table 4), the density coincides with studies done in Cañas, Costa Rica (Esquivel *et al.* 2011) and in the State of Mexico (Olivares-Perez *et al.* 2011). The low density of some trees in the grasslands and living fences may be to the result of damage and the mortality of plantlets, caused by the livestock in the paddock, the application of herbicides, and weeding done by the producers in their regular control practices (Olivares-Perez *et al.* 2011, Guerreiro *et al.* 2015). The predominant species show characteristics that facilitate their natural regeneration, abundant seed production and the ability to be spread by livestock after consumption. These aspects are important for the natural repopulation of these species (Villacis *et al.* 2003). The use of trees in living fences is beginning to become more important because of their durability and the economic saving to be made, especially in areas where the original vegetation has been disturbed by the multiple services provided by the trees (Olivares-Perez *et al.* 2011, Jimenez *et al.* 2015).

Non-leguminous foraging trees are found scattered in the grasslands and in living fences, and they play an important role in the preservation of biodiversity in silvopastoral systems by preserving habitats for wild animals, important for the natural spreading of tree seeds for natural regeneration (Olivares-Pérez *et al.* 2011, Gonzalez-Valdivia *et al.* 2014). At the same time, they act as biological corridors (Mastrangelo and Gavin 2014, Talamo *et al.* 2015).

Dasometric measurements of non-leguminous trees scattered in the grasslands and in living fences

The observed DBH ranges of 30.1 (+ ES12.3) to 44.4cm (+ ES 15.0) constitute an indicator of the low regeneration rate of the trees scattered in the grasslands and in living fences (Table 5). No trees were found with < 10 cm DBH for *F. glabrata, F. cotinifolia,* and *S. purpurea* (Figure 1). Studies performed in the dry tropics report DBH similar to those in this study (Tovar and Ibrahim 2010, Esquivel *et al.* 2011). Though natural regeneration of species was observed in the study, the livestock farmers control the density of the trees in their prairies. The high variation in DBH of some trees scattered in the grasslands and in living fences may be related to the handling practices of the producers regarding their grasslands and living fences (use of herbicides, frequency of trimming and weeding) that cause changes in growth (Tovar and Ibrahim 2010, Esquivel *et al.* 2011). This hinders the development of the trees and their production of abundant fruits for their natural regeneration. The above indicates that with time some desirable species in producers' systems might have low natural regeneration and, consequently, may be lost (Esquivel *et al.* 2011).

CONCLUSIONS

Non-leguminous trees are important in production units, both for their foliage and fruit supply for animal feeding in the low forage availability season and for their versatility, since they provide shade, firewood, posts and foliage in the LPU. The most important species, given their density and abundance, are *C. alata* and *G. ulmifolia*, which are selected by producers for their easy reproduction and because they are not invasive.

LITERATURE CITED

Barrance AJ, Flores L, Padilla E, Gordon JE, Schreckenberg K (2003) Trees and farming in the dry zone of southern Honduras I: *Campesino* tree husbandry practices. Agroforestry Systems 59: 97-106.

Bautista TM, López OS, Pérez HP, Vargas MM, Gallardo LF, Gómez MFC (2011) Sistemas agro y silvopastoriles en la comunidad el Limón, municipio de Paso de Ovejas, Veracruz, México. Tropical and Subtropical Agroecosystems 14: 63-76.

Cajas GYS, Sinclair FL (2001) Characterization of multistrata silvopastoral systems on seasonally dry pastures in the Caribbean Region of Colombia. Agroforestry Systems 53: 215-225.

Camacho M (2000) Parcelas permanentes de muestreo en bosque natural tropical. Turrialba, CR, CATIE 52p.

Couttolenc BE, Cruz RJA, Cedillo PE, Musálem MA (2005) Uso local y potencial de las especies arbóreas en camarón de Tejeda, Veracruz. Revista Chapingo Serie Ciencias Forestales y del Ambiente 11: 45-50.

Esquivel MH, Ibrahim M, Harvey AC, Benjamin T, Sinclair LF (2011) Dispersed trees in pasturelands of cattle farms in a tropical dry ecosystem. Tropical and Subtropical Agroecosystems 14: 933-941.

Gonzalez-Valdivia N, Barba-Macias E, Hernandez-Daumas S, Ochoa-Gaona S (2014) Avifauna en sistemas silvopastoriles en el Corredor Biológico Mesoamericano, Tabasco, México. Revista de Biologia Tropical 62: 1031-1052.

Grande D, De León F, Nahed J, Pérez-Gil F (2010) Importance and function of scattered trees in pastures in the sierra región de Tabasco, Mexico. Research Journal of Biological Sciences 5: 75-87.

Guerreiro MF, Franceschi NML, Porfírio DSV (2015) Vulnerability of ten eucalyptus varieties to predation by cattle in a silvopastoral system. Agroforestry Systems 89: 743-749.

Harvey CA, Haber WA (1999) Remnant trees and the conservation of biodiversity in Costa Rican pastures. Agroforestry Systems 44: 37-68.

Jiménez-Ferrer G, Mendoza-Martínez G, Soto-Pinto L, Alayón-Gamboa A (2015) Evaluation of local energy sources in milk production in a tropical silvopastoral system with *Erythrina poeppigiana*. Tropical Animal Health and Production 47: 903-908.

Lanna RG, Quintão LAM, Martins MR, Quintão LRM, Matta MR, Borges I, *et al*. (2010) Influence of trees on soil nutrient pools in a silvopastoral system in the Brazilian Savannah. Plant and Soil 329: 185-193.

Leon-Castro Y, Olivares-Perez J, Rojas-Hernandez S, Villa-Mancera A, Valencia-Almazan MT, Hernández-Castro E, *et al*. (2015) Effect of three fodder trees on *Haemonchus contortus* control and weight variations in kids. Ecosistemas y Recursos Agropecuarios 2: 193-201.

Lorenz K, Lal R (2014) Soil organic carbon sequestration in agroforestry systems. A review. Agronomy for Sustainable Development 34: 443-454.

Mastrangelo EM, Gavin CM (2014) Impacts of agricultural intensification on avian richness at multiple scales in Dry Chaco forests. Biological conservation 179: 63-71

McGroddy ME, Lerner AM, Burbano DV, Schneider LC, Rudel TK (2015) Carbon stocks in silvopastoral systems: A study from four communities in southeastern Ecuador. Biotropica 47: 407-415.

Nair PKR, Nair VD, Kumar BM, Haile SG (2009) Soil carbon sequestration in tropical agroforestry systems: a feasibility appraisal. Environmental Science & Policy 12: 1099-1111.

Nair PKR, Nair VD, Kumar BM, Showalter JM (2010) Chapter five - Carbon sequestration in agroforestry systems. Advances in Agronomy 108: 237-307.

Olivares PJ, Aviles NF, Albarran PB, Castelan OOA, Rojas HS (2013) Use of three fodder trees in the feeding of goats in the subhumid tropics in Mexico. Tropical Animal Health and Production 45: 821-828.

Olivares-Perez J, Avilés-Nova F, Albarrán-Portillo B, Castelán-Ortega O, Rojas-Hernandez S (2013) Nutritional quality of Pithecellobium dulce and Acacia cochliacantha fruits, and its evaluation in goats. Livestock Science 154: 74-81.

Olivares-Perez, J, Aviles-Nova F, Rojas-Hernandez S, Albarran-Portillo B, Castelan-Ortega OA (2011) Identification, uses and measurement of fodders legumes trees in south farmers of the States of Mexico. Tropical and Subtropical Agroecosystems 14: 739-748.

Palma JM (2006) Los sistemas silvopastoriles en el trópico seco mexicano. Archivos Latinoamericanos de Producción Animal 14: 95-104.

Pennington DT, Sarukhán J (2005) Árboles tropicales de México. Ed. Ediciones Científicas Universitarias. Tercera edición. Universidad Nacional Autónoma de México, México 523p.

Pinto RR, Gómez H, Martínez B, Hernández A, Medina FJ, Gutiérrez R, *et al.* (2005) Árboles y arbustos forrajeros del sur de México. Pastos y Forrajes 28: 87-98.

Prontuario de información geográfica municipal de los estados unidos Mexicanos (2009) Clave geoestadística 15082. http://www3.inegi.org.mx/sistemas/mexicocifras/datos-geograficos/15/15 082.pdf. Data consulted: octuber 12, 2015.

Reis LG, Quintão LAM, Martins MR, Quintão LRM, Matta MR, Borges I, *et al.* (2010) Influence of trees on soil nutrient pools in a silvopastoral system in the Brazilian Savannah. Plant and Soil 329: 185-193.

Rojas HS, Avilés NF, Castelán OOA, García MA, Olivares PJ, Valencia AMT (2012) Chemical Composition, in vitro digestibility of foliage *Guazuma ulmifolia* and *Crescentia alata* and its use in feeding lambs. Pakistan Journal of Nutrition 11: 1139-1145.

Rojas HS, Olivares PJ, Gutiérrez SI, Jiménez GR, León LF, Córdova IA (2013) Use of *Crescentia alata* and *Guazuma ulmifolia* fruits in lamb feeding in subtropical region of Guerrero, Mexico. Revista Científica FCV-LUZ XXIII: 157 - 162.

Rojas-Hernandez S, Olivares-Perez J, Elghandour MMMY, Cipriano-Salazar M, Avila-Morales B, Camacho-Díaz LM, *et al.* (2015) Effect of polyethylene glycol on in vitro gas production of some non-leguminous forage trees in tropical region of the south of Mexico. Agroforestry System 89: 735 - 742.

Solares AF (2004) Etnobotánica y usos potenciales de Cirián (*Crescentia alata*, H.B.K.) en el estado de Morelos. Polibotánica 18: 13-31.

Sosa REE, Pérez RD, Ortega RL, Zapata BG (2004) Evaluación del potencial forrajero de árboles y arbustos tropicales para la alimentación de ovinos. Técnica Pecuaria México 42: 129-144.

Steel RGD, Torrie JH (1988) Bioestadística: Principios y Procedimientos. R. Martínez B. (Trad.) 2.ª Ed. McGraw-Hill/Interamericana de México. Estado de México. 622p.

Talamo A, Barchuk A, Cardozo S, Trucco C, Maras G, Trigo C (2015) Direct versus indirect facilitation (herbivore mediated) among woody plants in a semiarid Chaco forest: A spatial association approach. Austral Ecology 40: 573-580.

Tobar LDE, Ibrahim M (2010) Las cercas vivas ayudan a la conservación de la diversidad de mariposas en paisajes agropecuarios. Revista de Biología Tropical 58: 447-463.

Villa HA, Nava TME, López OS, Vargas LS, Ortega JE, Gallardo LF (2009) Utilización del Guázimo (*G. ulmifolia* Lam.) como fuente de forraje en la ganadería extensiva del trópico mexicano. Tropical and Subtropical Agroecosystems 10: 253-261.

Villacis J, Harvey CA, Muhammad I, Cristóbal V (2003) Relaciones entre la cobertura arbórea y el nivel de intensificación de las fincas ganaderas en Río Frío, Costa Rica. Agroforestería en las Américas 10: 17-23.

Zamora S, García J, Bonilla G, Aguilar H, Harvey CA, Ibrahim M (2001) Uso de frutos y follaje arbóreo en la alimentación de vacunos en la época seca en Boaco, Nicaragua. Agroforestería en las Américas 8: 31-38.