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PRODUCTIVE BEHAVIOR OF SHEEP IN A SILVOPASTORAL SYSTEM OF *LEUCAENA LEUCOCEPHALA* ASSOCIATED WITH *MEGATHYRSUS MAXIMUS VAR*. MOMBASA VERSUS NATURAL FIELD

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Abstract: Planned silvopastoral systems can improve the productivity of pastoral livestock. The objective was to analyze characteristics of the forage plant canopy of three types of areas for sheep grazing: silvopastoral system *Leucaena leucocephala-Megathyrsus maximus* var. Mombasa at two densities of *L.leucocephala* and natural field in a low deciduous forest environment. The densities of *L. leucocephala* were 4700 and 2383 plant plants/ha. The variables were: amounts of forage offered (FO) and rejected (FR), daily forage allocation (ADF), harvest grade (GC), forage disappearance rate (TD), *in vitro* digestibility of dry matter (DIVMS), crude protein (CP) and concentration of eight minerals, which were determined in blood serum and weight of the sheep to calculate daily weight gain (GDP). The design was completely randomized with three repetitions. The natural field showed up to 50% less ($p \leq 0.05$) FO, FR, ADF and TD than the average of the two silvopastoral systems. The DIVMS of the herbaceous FO (Mombasa in silvopastoral systems) did not show a stable trend, but the PC did, which was 25% higher ($p \leq 0.05$) in the natural field. The DIVMS and CP in the FO of the tree layer were similar ($p > 0.05$) in the three types of grazing areas. The FO considering herbaceous and tree strata showed high levels of K and Fe, while, for Ca, Mg, Na and Zn, it is advisable to offer them in addition to the forage in the three types of grazing areas. The sheep in natural fields lost weight while those that grazed any silvopastoral systems gained weight. The silvopastoral system *Leucaena leucocephala-Megathyrsus maximus* var. Mombasa shows a forage canopy that can improve the productive behavior of livestock compared to the natural field of a low deciduous forest.

Keywords: minerals; daily forage allowance; daily weight gain.

INTRODUCTION

In tropical areas, pastoral livestock farming is based on grazing natural fields with trees (Genro and Silveira, 2018;Ibarra *et al.*, 2018). Contreras-Santos *et al.* (2020) pointed out that planned silvopastoral systems in terms of species and densities of woody and herbaceous plants can improve the productivity of pastoral livestock, in addition to collaborating in the rehabilitation of degraded soils, reducing the emission of greenhouse gases or mitigating the impact environmental of them.

Silvopastoral systems are agroforestry arrangements with herbaceous and tree forages, grasses and legumes among herbaceous plants, and legumes among trees, seeking to offer higher quality forage and environmental services (Améndola *et al.*, 2016; Chará *et al.*, 2020). Several authors (Oliva *et al.*, 2018, Díaz *et al.*, 2020; Gallego *et al.*, 2017; Gamarra *et al.*, 2018; Caicedo *et al.*, 2018; Oliva *et al.*, 2018; Vásquez *et al.*, 2020) conclude that silvopastoral systems, with herbaceous and tree plants relevant to the environment, facilitate productive pastoral livestock by providing sufficient forage in quantity and quality. Other authors (Escobar *et al.*, 2017; Pachas, 2017; González-Valdivia *et al.*, 2018; Escobar *et al.*, 2020) add that silvopastoral systems provide greater environmental services and biodiversity than grazing areas dominated by grasses.

Chará *et al.* (2020) emphasize, for the Latin American region, that the expansion and livestock and environmental benefits of silvopastoral systems will be derived from local validations of species, densities and topology.

In the tropical biome of low deciduous forest in southern Mexico, pastoral livestock farming is carried out on natural fields of native herbaceous and woody plants, even though there is evidence (Benítez *et al.*, 2010; Rivera-Herrera *et al.*, 2017) in this plant biome, that the productivity of pastoral livestock can be improved with respect to the natural field if planned silvopastoral systems are established with *Leucaena leucocephala* and *L. collinsii* and improved grasses. However, it remains to define characteristics of the plant canopy that explain the superiority of silvopastoral systems over the natural field.

Therefore, the objective of the study was to analyze characteristics of the forage plant canopy of the silvopastoral system *Leucaena leucocephala-Megathyrsus maximus* var. Mombasa and the natural countryside exploited by grazing in a low deciduous forest environment.

MATERIALS AND METHODS

The study was carried out in an area of the low deciduous forest biome within the El Limón ejido, Tepalcingo, Morelos. The annual precipitation is 900 mm concentrated in the four hottest months of the year, without precipitation in winter, the environmental temperature varies from 13 to 34oC with an annual average of 23oC (Dorado *et al*., 2005). There were three treatments: natural field and two arrangements of the silvopastoral system *Leucaena leucocephala-Megathyrsus maximus* var. Mombasa, 4700 and 2383 *L. leucocephala* plants/ha. The experimental design was completely randomized with three repetitions, the experimental unit was a 200m2 pasture.

The paddocks in *L. leucocephala-M. maximus* var. Mombasa, the year before starting the experimental grazing, seed was collected from a local individual of the first species, it was sown in plastic bags that were kept in the nursery for six months, at the beginning of the rainy season they were transplanted, the plantation was in single row 4m apart, within rows the separation from one plant to another was necessary to give the target densities, the grass was sown at the beginning of the rainy season of the year prior to the year in which the grazing was carried out, the density It was the equivalent of 5 kg of pure germinable seed/ha, sowing was broadcast.

The pastures in natural fields were only delimited, in them during the rainy season the dominant herbaceous stratum was species of the Asteraceae family, the arboreal included guácima (*Guazuma ulmifolia*), cubata (*Acacia cochliacantha*), huizache (*Acacia farnesiana*), casahuate (*Ipomoea murucoides*), tecolhuixtle (*Mimosa benthamii*) and guamúchil (*Pithecellobium dulce*) at a density of 300 trees/ha.

The experimental grazing was from October to November 2015, three groups of 4 sheep were formed (¾ Dorper ¼ Pelibuey), each group sequentially grazed each of the three paddocks of each treatment, with 15 days of occupation per paddock, the stocking density The animal size was 200 sheep/ha, grazing began when the grass completed 21 days of regrowth, after a homogenization cut.

In each paddock, forage offered (FO) and rejected (FR) were measured using the protocol of Gardner (1967) and Haydock and Shaw (1975); daily forage allowance (ADF) according to Hodgson (1979); harvest degree (GC) and forage disappearance rate (TD) applying the equation of Stuth *et al.* (1981). The quality of FO and FR was determined by *in vitro* digestibility of dry matter (DIVMS) with the technique of Tilley and Terry (1963) modified by Barnes (1969); crude protein (CP) by Microkjeldahl (AOAC, 1984); and, concentrations of Ca, Mg, Na. K, Cu, Fe, Zn and P, the first seven by atomic absorption spectrophotometer (Perkin Elmer) and the last by colorimetry using the UV/VIS spectrometer (Fick *et al*., 1979). FO and FR in quantity and quality were separated by herbaceous and woody strata, in the natural field paddocks they were weeds and foliage of the woody plants previously identified as consumed by sheep, in those of silvopastoral arrangements they were Mombaza and L. leucocephala, as strata herbaceous and woody, respectively. All plant tissue data were always based on dry matter.

At the beginning and end of each occupation period, the sheep were weighed to calculate daily weight gain (GDP), and at the beginning and end of the experimental grazing, blood samples were taken from the sheep to measure the same minerals in blood serum as in the Plant tissue. The sheep were always weighed with a prior eight-hour fast.

The statistical analysis was by analysis of variance, for the variables of quantity and quality of forage, the paddocks were the repetitions, for the variables of daily weight gain and concentrations of minerals in blood serum, each sheep was a repetition. To analyze the data, the general procedure for linear models (PROC GLM) of the statistical package SAS 9.4 (2014) was applied, in case of a significant effect (($p \leq 0.05$) the means were separated byTukey ($\alpha=0.05$).

RESULTS AND DISCUSSION

The natural field presented lower amounts of FO than the silvopastoral arrangements in the herbaceous and tree strata and therefore in the total, the FR of the herbaceous stratum of the natural field was reduced by 67% with respect to the average of the silvopastoral arrangements. Among the silvopastoral arrangements, the FO and FR of Mombaza remained unchanged ($p>0.05$) but the supply of foliage from *L. leucocephala* was reduced by 55% by reducing the density of this species by 49% (Table 1).

The greater FO of the silvopastoral arrangements than the natural field coincides with what was obtained by Echavarría *et al.* (2007) and Ibarra *et al.* (2018) these authors indicate that by incorporating species relevant to the physical and biological environment and with a history of improvement in forage production when forming silvopastoral arrangements, this result can be expected. Reid *et al.* (2014) add that native vegetation can be a poor source for feeding domestic livestock and the function of this vegetation is more associated with wild fauna.

The strong reduction in the FR of the herbaceous stratum of the natural field may imply poor basal soil cover after grazing by domestic livestock, leaving the soil with little cover makes it susceptible to erosive factors (Echavarría *et al.*, 2023). The improvement in soils in grazing areas with improved forage species could be associated with their coverage (Genro and Silveira, 2018).

L. leucocephala at a higher density allowed for greater FO, without detriment to the Mombaza FO, which allows us to point out that the higher density of *L. leucocephala* in the applied topology did not cause excessive shading on the grass canopy. Benitez *et al.* (2010) agree in not registering a positive or negative effect on FO of *Brachiaria brizantha* var. Freedom by varying the density of *L. leucocephala*; However, Bacab and Solorio (2011) and Azuara-Morales *et al.* (2018) found that grass increased FO by increasing the density of *L. leuecocephala*, so they concluded that the woody stratum may present positive effects of microclimate on the accumulation of the herbaceous stratum and not only governs competition for light.

The herbaceous stratum of the natural field showed an FO that could be considered high compared to those recorded by Miliani *et al.* (2008) in a grazing area in a lowland forest biome during the rainy period. For both densities, the FO of *L. leucocephala* was high when compared to data such as that of Hernández *et al.* (2020), but not the woody stratum of the natural field, which was very scarce. The high levels of herbaceous FO in the natural and woody field of *L. leucocephala*

Type of grazing area	FO by stratum and total			FR herbaceous layer
	Herbaceous	Woody	Total	
Silvopastoral 4700 leucaenas/ha	8935.9±506.2[a]	217.7±42.2[a]	9153.7±534.4[a]	2265.7±199.9[a]
Silvopastoral 2383 leucaenas/ha	7841.0±737.4[a]	97.7±24.8b	7938.7±754.6[a]	2806.6±231.4[a]
natural field	3711.9±108.8b	10.4±4.5c	3722.3±107.0b	827.4±83.7b

[a,b,c…]means in the same column with at least one letter in common are not different (Tukey, α = 0.05).

Chart1. Quantities in kg/ha (average±standard deviation) of forage offered (FO) and rejected (FR) in three types of grazing areas.

Type of grazing area	Grazing process parameters			GDP, g/sheep
	ADF (kg DM/100 kg BW/ day)	CG (%)	TD (kg DM/100 kg BW/ day)	
Silvopastoral 4700 leucaenas/ha	13.6±0.4[a]	75.1±2.4[a]	9.9±0.6[a]	53.7±9.4[a]
Silvopastoral 2383 leucaenas/ha	11.6±0.7[a]	64.5±1.0b	7.3±0.4[a]	64.8±18.3[a]
natural field	5.8±0.2b	77.7±2.6[a]	4.5±0.3b	-14.8±5.23b

[a,b,c…]Means in the same column with at least one letter in common are not different (Tukey, α = 0.05).

Chart2. Parameters of the grazing process,todaily forage allocation (ADF), harvest grade (GC), forage disappearance rate (TD) and daily gain of weight (GDP) of sheep (Mean±standard deviation)in three types of grazing areas

Type of grazing area	DIVMS (%)			PC (%)		
	herbaceous FO	FO - arboreal	herbaceous FR	herbaceous FO	herbaceous FR	FO - arboreal
Silvopastoral 4700 leucaenas/ ha	45.9±3.5[b]	66.6±1.5[a]	27.6±1.9[c]	7.8±1.1[b]	3.2±0.4[a]	22.7±1.8[a]
Silvopastoral 2383 leucaenas/ ha	60.7±2.4[a]	60.6±6.6[a]	55.9±2.2[a]	7.0±0.3b	3.6±0.7[a]	21.6±2.8[a]
natural field	60.6±6.1[a]	56.2±4.0a	47.1±1.7b	11.7±0.7[a]	7.3±3.9[a]	19.2±2.4[a]

[a,b,c..]Means in the same column with at least one letter in common are not different (Tukey, α = 0.05).

Chart3. Socks±standard deviation of din vitro igestibility of dry matter (DIVMS) and crude protein (CP) of forages offered (FO) and rejected (FR) in three types of grazing areas.

allow us to indicate that the soil characteristics were favorable for plant growth.

The ADF and TD were 54 and 48% lower ($p<0.05$) in the natural field compared to the average of the silvopastoral arrangements that showed no difference between them. The lower ADF in the natural field was associated with weight losses in the sheep, while in both silvopastoral arrangements the sheep showed a daily weight gain close to 60 grams (Table 2).

The higher GDP of sheep exposed to higher ADF in silvopastoral arrangements could be due to the fact that grazing animals with higher ADF have a greater opportunity to select the forage to consume and therefore higher quality forage and even a higher FR (Minson, 1971) as was the case in this study. Avendaño *et al.* (1986) indicate that at higher ADF, even when the forage on offer per animal is greater and more forage can be consumed, the amount of forage rejected may be greater than at lower ADF.

The silvopastoral arrangement with a lower density of *L. leucocephala* showed lower ($p<0.05$) GC than the one with a higher density, perhaps the sheep exposed to a higher density of *L. leucocephala* had a higher consumption of crude protein and therefore a higher consumption (Bacab and Solorio, 2011). In the three types of grazing areas the GC was higher than what was found by Benítez *et al.* (2010) who obtained CG of 58%.

The highest GDP of silvopastoral arrangements with *L. lecocephala* coincides with what was found by Medina and Sánchez (2006) andWood *et al.*(2013) who found that the inclusion of *L. leucocephala* caused a higher GDP and this response was not only explained by a higher quality of the forage offered but also by a possible lower parasite load in animals exposed to *L. leucocephala*. The GDP in the sheep of almost 60 grams exceeded the GDP of 28.35 g obtained by Alvarado-Canché *et al.* (2017) in a L. leucocephala-Cynodon plectostachyus with 6666 leucaenas/ha but lower than the 114 g obtained by Villanueva-Partida *et al.* (2019) in *L. leucocephala-Panicum máximum* with 36,000 leucaenas/ha, this disparity in the data could be explained, among other factors, by the quality of the accompanying grass.

In aspects of the quality of the forage offered, the natural field stands out with a herbaceous stratum with the maximum CP concentration almost four percentage units above the Mombaza average of the silvopastoral arrangements, in contrast, these showed the CP content of the tree stratum superior by about three percentage units with respect to the natural field. In DIVMS Mombaza in the silvopastoral arrangement with 4700 leucaenas/ha, it showed a very low value, possibly the higher density of the tree stratum caused a greater contribution of the stem component compared to the arrangement with a lower density of leucaenas (Table 3).

The natural field, despite high levels of PC in the herbaceous and tree strata, failed to promote GDP, which could be explained by the low level of FO in both strata, which caused a poor total consumption of dry matter and therefore poor productive performance. (NRC, 2007). This allows us to point out that the greater GDP productivity of the sheep compared to the natural field was based on the quantity of FO and not necessarily on the quality of the FO.

The PC and DIVMS of the FO of the tree layer of the natural field are adequate to promote livestock production; other authors agree in pointing out this situation, for example, Flores-Alberto *et al.* (2018) recorded 16.4 to 18% CP and Mayren-Mendoza *et al.* (2018) no less than 54% in DIVMS in *Guazuma ulmifolia* leaves; Hernández-Morales *et al.* (2018) found no less than 10.9% PC in *Acacia cochliacantha* pods; and, Zapata-

Campos *et al.* (2020) determined that *Acacia farnesiana* leaves contained 17.3 and 47.3% CP and DIVMS, respectively.

The PC of the Mombasa FO is lower than the values recorded by Munari *et al.* (2017) and Shintate *et al.* (2019), which allows us to point out that Mombaza in this study grew on a soil with poor N availability or that it was grazed at an advanced stage of maturity. The PC in the FO of leucaena was similar to what was found by Zapata-Campos *et al.* (2020) and a little higher than that recorded by Bottini-Luzardo *et al.* (2016).

In the three types of grazing areas and both strata (herbaceous and tree) the FO showed concentrations of Ca, P, K and Mg within or above, and those of Na below that proposed by the NRC (1985) therefore, the differences in the concentrations of these macroelements in the FO are no longer important in terms of livestock feeding (Table 4).

The relatively high concentration of Ca in the FO, Puls (1988) does not consider it to be at risk of causing any disorder; the NRC (1985) also considers this concentration to be risk-free because it does not exceed 2%. Na is scarce in plant tissue because it is not an essential element for plants, and in soil it is easy to leach (Cardona*et al.*, 2017).

In the three types of grazing areas and both strata (herbaceous and arboreal), the FO recorded values of Zn below and Fe above those suggested for each micromineral by the NRC (1985). In the case of Cu, the herbaceous stratum was highlighted. of the natural field with a concentration within the interval suggested by this instance, while in none of the strata of the silvopastoral arrangements it was present (Table 5).

The high concentrations of Fe in the FO cannot be considered high risk for the health status of the sheep as they do not reach the level of 500 ppm (NRC, 1985).

At the beginning of experimental grazing, all sheep showed similarity ($p>0.05$) in blood serum concentrations of macro and microminerals (data not shown). Table 6 shows these concentrations at the end of experimental grazing.

Only the concentration of P in blood serum showed an effect ($p<0.05$) of the type of grazing area, the maximum concentration was in the sheep from the silvopastoral arrangement with the highest density of leucaena, almost 12% higher than the average for the sheep. that they grazed in the other two types of areas without difference between them; However, it is irrelevant since in all cases the P concentration is well above the recommended range for this mineral (Table 6).

The high concentration of P in all sheep could explain the low concentration of Ca in all of them (Table 6) even when the Ca content in the herbaceous and shrubby forage offered was within the acceptable level (Table 4). The Ca deficiency in blood serum could be a consequence of the high P intake (Suttle, 2010). Puls (1988) and Mc Dowell (1996) emphasize that the Ca:P ratio in the diet must be 1.5:1.0 to 2.0:1.0 to avoid negative interactions between these minerals within the animal, the forage offered in the herbaceous and tree strata of the three types of areas for grazing showed a Ca:P ratio lower than that proposed by these authors. Following up on this situation, it could be pointed out that offering additional Ca is an option, or seeking a higher density of trees that showed forage offered with a Ca:P ratio closer to what is recommended. Possibly all sheep had a hypocalcemia condition as recommended by NRC (1985).

Mg deficiency was also found in all sheep regardless of the type of grazing area, as in Ca, the generalized deficiency could be explained by an antagonistic relationship, in this case with K(Evans *et al.*, 1983; Sepúlveda *et al.*, 2011) when the concentration of K in

Mineral type of forage and layer	Type of grazing area			R.O.
	Silvopastoral with		natural field	
	4700 leucaenas/ha	2383 leucaenas/ha		
Ca FOH	0.41±0.03[b]	0.40±0.10[b]	1.24±0.03[a]	
Ca FRH	0.18±0.01[a]	0.28±0.04[a]	0.77±0.29[a]	0.20-0.82
Ca FOA	1.59±0.25[a]	1.61±0.24[a]	1.62±0.33[a]	
P FOH	0.81±0.01[a]	0.83±0.01[a]	0.84±0.04[a]	
P FRH	0.76±0.05[a]	0.78±0.03[a]	0.74±0.13[a]	0.16-0.38
P FOA	0.81±0.04[a]	0.78±0.02[a]	0.79±0.07[a]	
K FOH	1.44 ±0.11[a]	1.78 ±0.02[a]	1.94±0.41[a]	
K FRH	1.69 ±0.39[a]	1.92 ±0.18[a]	1.63±0.51[a]	0.50-0.80
K FOA	1.12±0.05[a]	1.07±0.19[a]	0.93±0.31[a]	
Mg FOH	0.22±0.07[b]	0.22±0.02[b]	0.40±0.02[a]	
Mg FRH	0.16±0.04[a]	0.19±0.03[a]	0.15±0.05[a]	0.12-0.18
Mg FOA	0.46±0.05[a]	0.40±0.12[a]	0.37±0.04[a]	
Na FOH	0.009±0.002[a]	0.009 ±0.001[a]	0.007±0.001[a]	
Na FRH	0.004±0.0007[b]	0.006±0.0009[a]	0.005±0.0007 [ab]	0.09-0.18
Na FOA	0.003±0.0007[a]	0.004±0.001[a]	0.004±0.0003[a]	

[a,b,c..]Means in the same row with at least one letter in common are not different (Tukey, α = 0.05). RO = requirements in % of macrominerals for sheep (NRC, 1985).

Chart4. Half±standard deviation of concentration (%) ofmacrominerals in forage offered (FO) or rejected (FR), herbaceous or tree strata, and three types of grazing areas.

Mineral type of forage and layer	Type of grazing area			R.O.
	Silvopastoral with		natural field	
	4700 leucaenas/ha	2383 leucaenas/ha		
Zn FOH	10.10±1.48[b]	9.95±2.10[b]	17.22±2.98[a]	
Zn FRH	12.71±2.52[a]	12.90±2.27[a]	13.66±3.22[a]	20-33
Zn FOA	5.76±0.27[a]	6.17±0.56[a]	7.88±1.66[a]	
Cu FOH	5.01±1.43[b]	3.94±0.81[b]	8.52±1.20[a]	
Cu FRH	2.54±0.42[a]	2.72±0.02[a]	7.05±2.25[a]	7-11
Cu FOA	4.67±0.98[a]	5.21±1.08[a]	5.08±1.10[a]	
Fe FOH	58.25±2.05[b]	55.49±12.62[b]	114.23±15.39[a]	
Faith FRH	86.67±23.90[a]	92.17±21.01[a]	164.20±51.45[a]	30-50
Faith FOA	133.17±8.58[a]	123.36±36.60[a]	125.72±24.86[a]	

[a,b,c..]Means in the same row with at least one letter in common are not different (Tukey, α = 0.05). RO = requirements in ppm of microminerals for sheep (NRC, 1985).

Chart5. Half±standard deviation of concentration (ppm) ofmicrominerals in forage offered (FO) or rejected (FR), herbaceous or tree strata, and three types of grazing areas

Mineral	Type of grazing area			NA
	Silvopastoral with		natural field	
	4700 leucaenas/ha	2383 leucaenas/ha		
AC	74.8 ±3.5[a]	80.7 ±4.3[a]	85.9 ±6.6[a]	90-130
Q	121.1 ±4.4[a]	109.2 ±3.7[ab]	107.2 ±2.6[b]	40-80
K	137.9 ±31.5[a]	167.5 ±36.3[a]	191.7 ±31.8[a]	156-214.5
Mg	6.0 ±1.4[a]	7.7 ±0.5[a]	8.0 ±2.2[a]	20-35
na	1471.7 ±52.6[a]	1458.0 ±161.8[a]	1454.1 ±75.8[a]	3220-3611
Zn	0.557 ±0.032[a]	0.546 ±0.075[a]	0.598 ±0.014[a]	0.8-1.2
Cu	0.739 ±0.074[a]	0.802 ±0.134[a]	0.776 ±0.070[a]	0.7-2.0
Faith	2.9 ±0.3[a]	2.3 ±0.6[a]	2.8 ±0.7[a]	1.66-2.22

[a, b, c,…]Means in the same row with at least one literal in common are not different (Tukey, $\alpha = 0.05$). NA, adequate interval (Puls, 1988)

Table 6. Average±standard deviation of the concentration (mg L-1) of eight minerals in blood serum of sheep after completing 60 days of grazing in three types of areas.

the forage offered exceeds 1%, additional Mg must be offered (Suttle, 2010).Charlton and Armstrong (1989)mentioned that potassium-magnesium antagonism is aggravated when Na concentrations in diet and blood serum are poor, as is the case in this study. Sheep fed in any type of grazing area in the Sierra de Huautla must be offered additional Na and Mg, which may improve daily weight gain compared to that recorded in the study.

The concentration of Zn in blood serum was also below the recommended in all sheep, unlike Ca and Mg, Zn deficiency can be directly related to the poor concentration of this mineral in the forage offered in the three types of grazing areas. The feeding of grazing sheep must be complemented with an additional source of Zn to stimulate consumption, improve weight gain and semen quality, and reduce the risk of skin damage (González-Domínguez, 2016).

The sheep in the three types of grazing areas showed sufficiency of Cu in blood serum, possibly this is associated with the fact that in the dry season the sheep are offered manure (bedding plus broiler chicken feces) to the sheep's diet. In the analysis of manure of different origins, a range of 23 to 161 ppm has been recorded (Pacheco *et al*., 2003) and from 69.6 to 74.2 ppm (Pinto *et al*., 2019), in some cases it was recommended to control the consumption of chicken manure to reduce the risk of Cu poisoning.

Therefore, the objective of the study was to analyze characteristics of the forage plant canopy of the silvopastoral system *Leucaena leucocephala-Megathyrsus maximus* var. Mombasa and the natural countryside exploited by grazing in a low deciduous forest environment.

CONCLUSIONS

In a low deciduous forest environment the silvopastoral system *Leucaena leucocephala-Megathyrsus maximus* var. Mombasa at low and high densities of *L. leucocephala* is an option for improving pastoral livestock by providing a forage plant canopy superior to the natural field.; However, in the natural field there are elements with forage potential, so a total and radical replacement of the natural field with a silvopastoral system must not be considered *Leucaena leucocephala-Megathyrsus maximus* var. Mombasa.but rather a strategy of complementation between both types of grazing areas.

In both, silvopastoral system and natural field in a low deciduous forest environment, the feeding of grazing animals must be complemented with the minerals Ca, Mg, Na and Zn to ensure better productive behavior of said animals.

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