Ewe daily-weight gain grazing *Leucaena leucocephala-Megathyrsus maximus* CV Mombasa silvopastoral system and tropical native unimproved range

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Abstract: Silvopastoral systems are a viable option to increase livestock productivity, The silvopastoral arrangement of *Leucaena leucocephala* associated with *Megathyrsus maximus* CV Mombasa (LMS) is successfully cultivated in tropical environments.. The objective of the study was to determine ewe daily-weight gain grazing LMS and a tropical unimproved native range. Two LMS were tested: high and low leucaena densities, 4700 and 2383 plants/ha, respectively. Grazing was rotational, lasted 150 d (rainy season) at equivalent stocking rate of 59 ewes/ha/150 d. Experimental design was a completely random design with three replications, the experimental unit was a 192 m^2 plot. Variables measured on plots were amount (dry matter basis), *in vitro* dry matter digestibility (IVDMD), and crude protein (CP) of forage on-offer, from mixed samples herbaceous and tree fodder. Weight and serum concentrations of Ca, P, K, Mg, Na, Zn, Cu, and Fe were measured in ewes, daily weight gain was calculated. On average forage on-offer and IVDMD concentration were 50 and 15% higher ($p<0.05$) in LMS than in native range, respectively, with no difference between LMS. CP concentration was 25% higher ($p<0.05$) in native range than both LMS, with no difference between them. LMS's showed no difference ($p>0.05$) between them on ewe daily weight gain, on average 59.2 g, and were higher than native range where ewes showed a mean daily weight loss of 14.8 g. Serum concentrations of the 8 minerals measured were similar ($p>0.05$) across all ewes regardless the treatments. It was concluded that the *Leucaena leucocephala-Megathyrsus maximus* CV Mombasa silvopastoral system is an option to improve livestock productivity compared with unimproved native range due to higher forage on-offer.

Introduction

Silvopastoral systems are sustainable livestock production alternatives as they improve both animal production indicators and environmental services (Gallego *et al*., 2017). Sierra of Huautla is a protected reserve, in the state of Morelos, Mexico, and within its boundaries there are some communal tropical rangelands that support livestock grazing, from which small-holder farmers obtain some income. However, animal production indicators are low and some land and vegetation degradation have been associated to inadequate rangeland management and lack of rehabilitation protocols.

Silvopastoral systems adapted to the area could be an option to fight these two conditions: poor animal production and land and vegetation degradation (Murgueitio *et al*., 2014). Alonso (2011) reported that silvopastoral systems with legume species improve soil fertility and cover, while Gaviria-Uribe *et al*. (2015) added that planned silvopastoral systems that provide forage and browse increase total feed on-offer compared to single species pastures. The objective of the study was to compare the quantity and quality of forage and browse offered, as well as the changes in live weight in sheep at silvopastoral systems of Leucaena leucocephala associated with Megathyrsus maximus CV Mombasa and an unimproved native range.

Methods and Study Site

The study was carried out in El Limón, Tepalcingo, Morelos, Mexico within the Huautla Sierra protected area, that has a semi-arid (up to 7-8 months of drought) tropical climate and vegetation of deciduous shrubs and low trees. Three treatments were evaluated: *Leucaena leucocephala-Megathyrsus maximus* CV Mombasa silvopastoral systems at two *L. leucocephala* densities, high (LMSH) and low (LMSL) and a control treatment of native unimproved range (NUR). Experimental design was a completely randomized design with three treatments and three replications. The experimental unit was a 192 m^2 plot.

LMSH and LMSL were established and fenced at the start of the rainy season of the year before experimental grazing was carried out, NUR plots were fenced at this time as well. Leucaena plants were grown in nursery for two months prior to planting on the field. Planting of leucaena plants was done in rows 2m apart, at 4700 and 2383 plants/ha for LMSH and LMSL, respectively, Mombasa grass was sown in rows within leaucaena rows at 8 kg seed/ha. Experimental grazing lasted 150 d during the 2015 rainy season, just before grazing started tree/shrub count was done in the NUR plots, on average they showed 300 plants/ha. Grazing was rotational with 21-28 d of resting, the stocking rate was 59 ewes/ha.

Variables assessed were: on-offer (Haydock & Shaw, 1975) forage and browse on dry matter basis, *in vitro* dry matter digestibility (IVDMD; Barnes, 1969) and crude protein (CP; AOAC, 1984); and, ewe weight and serum Ca, P, K, Mg, Na, Zn, Cu, and Fe concentrations (Fick *et al*., 1979), daily weight gain was calculated, serum mineral concentrations were determined at the start and end of the experimental grazing. Statistical analysis was by analysis of variance using PROC GLM of SAS (SAS 9.4, 2014). If a main effect was significant ($p \leq 0.05$) least square mean multiple comparison was done using Tukey at $\alpha = 0.05$.

Results

LMSH and LMSL had similar ($p>0.05$) yield of forage on-offer which was 2.2 times higher ($p<0.05$) than NUR, while in browse on-offer LMSH had the highest yield which was 2.2 and 22 times higher than LMSL and NUR, respectively; however, LMSH and LMSL provided similar ($p>0.05$) total feed on-offer during the rainy season (Table 1).

Table 1. Forage, browse and total feed on-offer (kg DM/ha) at three systems during the rainy season.

Silvopastoral system	Forage	Browse	Total feed
LMSH*	8936 ± 506.2^{a}	218 ± 42.2^{a}	9154 ± 534.4^{a}
LMSL	7841 ± 737.4^{a}	98 ± 24.8^{b}	7939 ± 754.6^{a}
NUR	3712 ± 108.8^{b}	10 ± 4.5^{c}	3722 ± 107.0^{b}

*LMSH, *Leucaena leucocephala-Megathyrsus maximus* at 4700 plants/ha; LMSL, *Leucaena leucocephala-Megathyrsus maximus* at 2383 plants/ha; NUR, native unimproved range at 300 trees/ha. Means within columns with one letter in common are not statistically different (Tukey, α=0.05).

Silvopastoral system influenced ($p<0.05$) IVDMD and CP of forage on-offer, with no effect ($p>0.05$) on browse on-offer quality measurements. LMSH showed the lowest forage IVDMD on-offer, while NUR had 1.5 times higher forage CP on-offer than the mean of the other two silvopastoral systems that had similar CP content in the forage on-offer. Ewes grazed on NUR lost ($p<0.05$) weight while ewes grazed on the two leucaena systems had similar weight gain ($P > 0.05$) (Table 2).

Table 2. *In vitro* dry matter digestibility (IVDMD), crude protein (CP) of forage and browse on-offer and ewe daily weight gain (DWG) at three systems.

Silvopastoral system	IVDMD(%) on-offer		CP(%) on-offer		DWG, g/ewe/day
	Forage	Browse	Forage	Browse	
LMSH*	46 ± 3.5^{b}	67 ± 1.5^{a}	7.8 ± 1.1^{b}	22.7 ± 1.8^{a}	53 ± 9.4^{a}
LMSL	61 ± 2.4^{a}	61 ± 6.6^{a}	7.0 ± 0.3^{b}	21.6 ± 2.8^{a}	65 ± 18.3^{a}
NUR	61 ± 6.1^{a}	56 ± 4.0^{a}	11.7 ± 0.7^{a}	19.2 ± 2.4^{a}	-15 ± 5.23^{b}

*LMSH, *Leucaena leucocephala-Megathyrsus maximus* at 4700 plants/ha; LMSL, *Leucaena leucocephala-Megathyrsus maximus* at 2383 plants/ha; NUR, native unimproved range at 300 trees/ha. Means within columns with one letter in common are not statistically different (Tukey, α=0.05).

Mineral serum concentrations were similar ($p>0.05$) among ewes regardless the silvopastoral system assigned, with the exception of P content, where ewes grazed on NUR had 13% less P than ewes grazed on LMSH at the end of the experimental grazing period. At the end of the experimental period, ewes grazed on all three systems had lower concentrations of Mg, Na, and Zn than those reported by Puls (1988; Table 3).

Table 3. Mineral serum concentrations (mg/L) in ewes at the start and end of experimental grazing in three systems.

Silvopastoral system	Mineral							
	Ca	P	K	Mg	Na	Zn	Cu	Fe

Start	72 ± 0.8^{a}	106 ± 2.5^{b}	170 ± 32.5^{a}	9.7 ± 1.8^{a}	1461 ± 7.5^{a}	0.2 ± 0.043^{b}	0.7 ± 0.099^{a}	2.1 ± 0.9^{a}
LMSH	74 ± 3.5^{a}	121 ± 4.4^{a}	137 ± 31.5^{a}	6.0 ± 1.4^{a}	1471 ± 52.6^{a}	0.5 ± 0.032^{a}	0.7 ± 0.074^{a}	2.9 ± 0.3^{a}
LMSL	80 ± 4.3^{a}	109 ± 3.7^{ab}	167 ± 36.3^{a}	7.7 ± 0.5^{a}	1458 ± 61.8^{a}	0.5 ± 0.075^{a}	0.8 ± 0.134^{a}	2.3 ± 0.6^{a}
NUR	85 ± 6.6^{a}	107 ± 2.6^{b}	191 ± 31.8^{a}	8.0 ± 2.2^{a}	1454 ± 75.8^{a}	0.5 ± 0.014^{a}	0.7 ± 0.070^{a}	2.8 ± 0.7^{a}
R	90-130	40-80	156-214	20-35	3220-3611	0.8-1.2	0.7-2.0	1.66-2.22

[*]LMSH, *Leucaena leucocephala-Megathyrsus maximus* at 4700 plants/ha; LMSL, *Leucaena leucocephala-Megathyrsus maximus* at 2383 plants/ha; NUR, native unimproved range at 300 trees/ha; R, suggested concentration (Puls, 1988). Means within columns with one letter in common are not statistically different (Tukey, α=0.05).

Discussion [Conclusions/Implications]

Planned arrangement of fodder trees (leucaena) and introduction of an improved grass (cv Mombasa) caused a large increase in the supply of forage, browse and total feed in the silvopastoral system treatments compared to the native distribution area. In these systems 8 and 16 times more trees were used than those found in the native range. The above, added to the fodder vocation of leucaena, explain the greater amount of browse in silvopastoral systems. Echavarría *et al*. (2007) agree on these both conditions to explain the higher feed available in planned silvopastoral systems compared with native ranges. Torres-Acosta *et al*. (2008) reported that in planned silvopastoral systems fodder trees are kept at a similar canopy height, while in native range upper canopy could be variable in height and then in browse yield. Reid *et al*. (2014) pointed out that in the evaluation of planned silvopastoral systems wildlife feeding and shelter should be determined in addition to animal production of livestock.

The better ewe performance measured by daily weight gain in both leucaena systems compared with the NUR, could be explained on basis of the higher amount of feed on-offer in those two lucaena systems, rather to differences in feed quality. The IVDMD and CP were similar for browse on-offer in all treatments, which shows that the nutritional value of the trees found in the native range is similar to that of leucaena. This highlights the fodder potential of these species and the need to include them in the design of silvopastoral arrangements to evaluate their performance. The IVDMD of forage on-offer was lower in the treatment with a higher density of leucaena. The CP of forage on-offer was higher in the native range. This shows that the herbaceous plants of the native range have a higher nutritional value than the grass cv Mombasa. The only mineral that presented variations during the experiment was phosphorus in the treatment with the highest amount of leucaena. It can be deduced that the duration of this work was not sufficient to observe an effect on the concentration of minerals in the blood serum of the animals that grazed in the treatments.

It was concluded that planned silvopastoral systems based on *Leucaena leucocephala* at high plant density along with an improved tropical grass are an option to improve animal performance compared with native tropical range. Environmental services of such planned silvopastoral systems are still to be elucidated.

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References

Alonso, L.J. 2011. Los sistemas silvopastoriles y su contribución al medio ambiente. *Revista Cubana de Ciencia Agrícola*, 45(2): 107-115.

AOAC. 1984. *Official methods of analysis of the association of official analytical chemists*. Virginia.

Barnes, R.F. 1969. Collaborative research with the two stage *in vitro* rumen fermentation technique. In: *Proceedings of the National Conference of Forage Quality Evaluation and Utilization*. Nebraska Center for Continuing Education. Lincoln, Nebraska, pp 2-20.

Echavarría, F.G.C., Serna, P.A. y Bañuelos V.R. 2007. Influencia del sistema de pastoreo con pequeños rumiantes en un agostadero del semiárido Zacatecano: II Cambios en el suelo. *Técnica Pecuaria en México*, 45(2): 177-194.

Fick, K.R., McDowell, L.R., Miles, P.H., Wilkinson, N.S., Funk, J.D., Conrad, J.H. y Valdivia R. 1979. Métodos de análisis de minerales para tejidos de plantas y animales. Universidad de Florida, Florida.

Gallego, L.A., Mahecha, L. y Angulo, A.J. 2017. Calidad Nutricional de *Tithonia diversifolia* Hemsl. A Gray bajo tres sistemas de siembra en el trópico alto. *Agronomía Mesoamericana,* 28(1): 213–222.

Gaviria-Uribe, X., Naranjo-Ramírez, J.F., Bolívar-Vergara, D.M. y Barahona-Rosales, R. 2015. Consumo y digestibilidad en novillos cebuínos en un sistema silvopastoril intensivo. *Archivos de Zootecnia*, 64(245): 21-27.

Haydock, K.P. and Shaw, N.H. 1975. The comparative yield method for estimating dry matter yield of pasture. *Australian Journal of Experimental Agriculture and Animal Husbandry*, 15: 663-670.

Murgueitio, R.E., Chará, O.J., Barahona, R.R., Cuartas, C.C. y Naranjo, R.J. 2014. Los sistemas silvopastoriles intensivos (SSPi), herramienta de mitigación y adaptación al cambio climático. *Tropical and Subtropical Agroecosystems,* 17(3): 501-507.

Puls, R. 1988. *Mineral Levels in Animal Health: Diagnostic Data*. Sherpa International, British Columbia.

Reid, R.S., Fernández-Giménez, M.E. and Galvin, K.A. 2014. Dynamics and resilience of rangelands and pastoral peoples around the globe. *Annual Review of Enviroment and Resource,* 39: 217-242.

SAS. 2014. *SAS user´s guide V 9.4.* SAS Institute Inc. SAS Campus Drive, North Carolina.

Torres-Acosta, J.F. de J., Alonso-Díaz, M.Á., Hoste, H., Sandoval-Castro, C.A., and Aguilar-Caballero, A.J. 2008. Efectos negativos y positivos del consumo de forrajes ricos en taninos en la producción de caprinos. *Tropical and Subtropical Agroecosystems*, 9(1): 83-90.