Scientific Paper

Effect of the presence of shade in sheep grazing areas. 1. Selection of forage species

Omar Encinozo-González[1], Selina Camacaro-Calvete[1]*, Livia Pinto-Santini[1] and Leyla Ríos-de Álvarez[2]

[1]*Facultad de Agronomía, Universidad Central de Venezuela*
Avenida Casanova Godoy vía El Limón, apdo. postal 4579, Maracay, Venezuela
[2]*Corporación Colombiana de Investigación Agropecuaria (CORPOICA), Centro de Investigación Tibaitatá, Cundinamarca, Colombia*
**Corresponding author, e-mail: camacaroset@gmail.com*

Abstract

In order to evaluate the effect of shade on the selection of forage species by grazing sheep, a trial was conducted at the Experimental Sheep Unit, Animal Production Institute, School of Agronomy, Central University of Venezuela. Twenty four West African ewe lambs were used (18,73 ± 2,36 kg), randomly distributed in two treatments: T1: no shade (NS) and T2: shade (S). The shade was provided by a canopy of synthetic mesh (70 % shade) placed at a height of 2 m for a 36-m^2 covered area, over enclosed pastures (0,13 ha) sown with *Cynodon nlemfuensis*. The plant species were identified and the height, cover and biomass production were measured. The grazing animals were observed (15 min/animal) with binoculars in two time periods: 9:30 a.m. to 10:00 a.m. and 1:00 p.m. to 1:30 p.m., and the intake per species and consumed plant part were recorded. Twenty seven species belonging to 14 families were identified. The variables plant height and cover differed per treatment ($p \leq 0.05$), and biomass production was affected by treatment, sampling and stratum ($p \leq 0.05$). The species with the highest selection percentage by the animals was *C. nlemfuensis* (95 %). Leaf intake was higher during the morning period (96 %) than the afternoon period (71 %). It is concluded that artificial shade influenced the forage species selection by the ewe lambs.

Keywords: height, biomass, sheep

Introduction

The sheep population in Venezuela is 601 207 heads (FAO, 2016) and its production is varied and diverse: from family production farms, of fattening, to extensive, semi-intensive and intensive systems with certain degree of technological innovation (Rondón *et al*., 2001), in certain agroecological regions (González and Rojas, 1985).

Climate factors (ambient temperature, relative humidity, wind speed and solar radiation) exert a strong influence on the feed voluntary intake, digestibility, metabolism and dissipation of body heat, with drastic reductions in productive indexes of sheep such as: milk and meat production, wool production and carcass quality ((Romano and Martínez, 2003). Against the climate effects, shade is an alternative to minimize their impact, because it improves the thermal welfare status of the animal. For such reason changes can be expected in the productive response of sheep (Olivares and Waldo, 1998; López *et al*., 2015) and in the performance under grazing conditions (selectivity) in the presence of shade.

On the other hand, it is known that there are plant species more tolerant to shade that others, and that with different shade levels there can be variations in their biomass production, higher crude protein content and reduction of structural carbohydrates, which causes changes in animal selectivity (Piñeros *et al*., 2011).

Due to the above-explained facts, the objective of this study was to evaluate the effect of artificial shade on the selection of forage species by sheep.

Materials and Methods

Location. The study was conducted in the sheep laboratory-section of the Animal Production Institute (IPA for its initials in Spanish), School of Agronomy of the Central University of Venezuela (FAGRO-UCV, for its initials in Spanish) –in Maracay, Aragua state, Venezuela–, located at 10º 16' 20" NL and 67º 36' 35", and at 443 m.a.s.l.. The duration of the trial was 33 days, during the rainy season.

Climate. The climate corresponds to tropical sub-humid dry forest (Holdridge, 1982), with mean temperature of 25,3 ºC, mean relative humidity of 72,2 % and annual average rainfall of 1 038,2 mm, which is in correspondence with four periods: a dry one from November to April, pre-rainy from April to June, rainy from June to October, and a post-rainy one from October to November (USICLIMA, 2013).

Soil. The soil shows loamy-sandy texture, slightly alkaline pH, moderate content of organic matter, high phosphorus content and moderate to low fertility (Camacaro and Machado, 2005).

Management of the enclosed pastures. Two enclosed pastures were used (one for each treatment) with a surface of 0,13 ha/enclosed pasture, planted with star grass (*Cynodon nlemfuensis*). Their general management was rotational (40-60 resting days); however, for the purposes of the trial grazing was continuous. No irrigation was applied and the stocking rate was 1,24 AU/ha.

Management of the animals. Twenty four West African ewe lambs were used, younger than one year old, weaned and with an initial weight of 18,73 ± 2,63 kg. The management was made under semi-confinement conditions, with *ad libitum* water availability. The animals were fed with a basal diet that consisted in grazing in the day hours (8:00 a.m. to 3:00 p.m.) and confinement in the night hours (3:00 p.m. to 8:00 a.m.); they also received supplementation with minerals and were supplied a mixture (250 g/animal/day) of brewery waste and concentrate feed (16 % CP), in a 3:1 ratio.

Evaluated variables

Vegetation management. A linear transept of 70-m length was used for each enclosed pasture area (Gómez, 2008), diagonally located with regards to the longest side of the enclosed pasture area, in order to cover the possible variations of vegetation and soil due to the slope and drainage (fig. 1), because the enclosed pasture areas were consecutively located at the base of a mountain.

For sampling purposes the vegetation was divided into three vertical strata (1: > 60 cm, 2: 40-60 cm, and 3: 0-40 cm). The variables height, cover and biomass production were evaluated once per week during five weeks, alternating every 5 m on both sides of the transept the location of square frames of 50 x 50 cm (0,25 m^2).

Botanical composition. The identification of the species was made before starting the trial and botanical samples were collected which were compared with those of the botanical herbarium Dr. Víctor M. Badillo (MY), Botanical Institute, FAGRO-UCV. The species were classified as desirable (D) and less desirable (LD), according to the observations with grazing animals before the essay.

Plant height. Plant height was determined as the shortest distance between the higher limit of a plant crown and the soil level. In each sampling

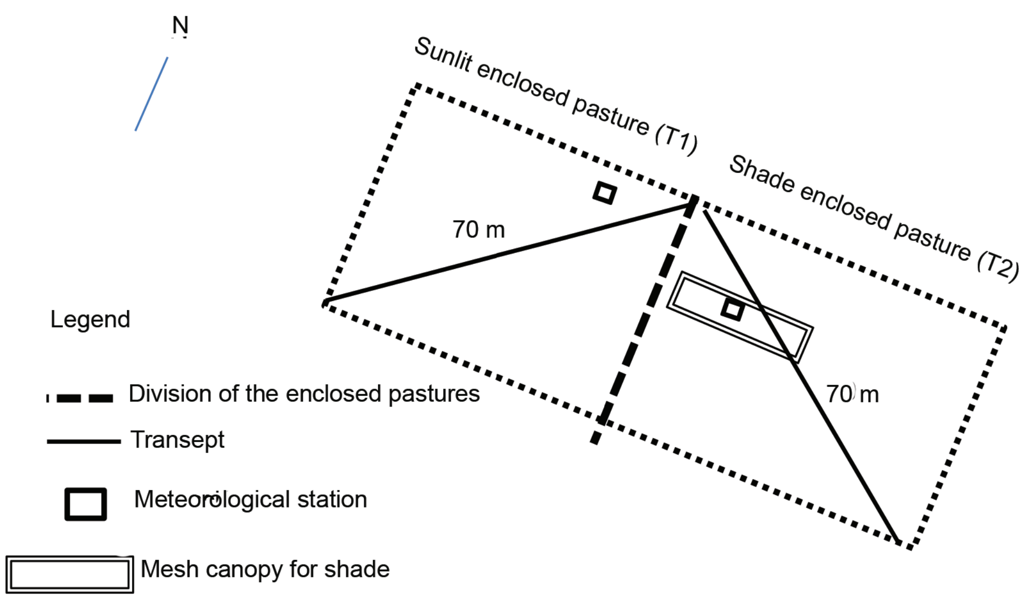

Figure 1. Location of treatments and field divisions.

frame three measurements were made, with a metric tape adhered to a wooden bar.

Cover of the herbaceous stratum. The cover of the herbaceous stratum was visually estimated as the vertical projection of the biomass on the soil within the frame, and it was expressed in percentage (Gómez, 2008).

Biomass production. The samples were harvested at 5 cm from the soil and were weighed in the field. Afterwards, they were placed in stove at 100 ºC until reaching constant weight, to determine the dry matter (DM). The biomass was expressed in the following variables: leaf dry matter (LDM), stem dry matter (STDM), senescent dry matter (SDM), dry matter of less desirable species (LDDM), total dry matter (TDM) and edible dry matter (EDM: LDM + SDM).

Selection of forage species. The observations were made three times per week at two moments of the day: from 9:30 to 10:00 a.m. and from 1:00 to 1:30 p.m., during 15 minutes in each treatment. Each animal was observed with binoculars to identify the plant species, the consumed parts and the intake stratum (Camacaro *et al*., 2016). When the animals were not eating, the observation was quantified as "performing another activity" (lying, standing, ruminating, etc.).

Experimental design. A completely randomized design was used in which 2 groups of 12 ewe lambs, balanced by initial weight, were assigned to each treatment: T1: grazing without shade (NS) and T2: grazing with shade (S). The shade was contributed by mesh canopies for synthetic shade (70 % shade) for a covered surface of 36 m^2.

Statistical analysis. The data of height, cover and biomass production were analyzed through an ANAVAR (Steel and Torrie, 1985), and the treatments, stratum and sampling were the sources of variation. The mean comparison was carried out through Tukey's multiple comparison test for highly significant ($p \leq 0,01$) and significant values ($p \leq 0,05$). For the comparison of means of defoliation patterns (species, consumed parts and enclosed pasture zones) the Chi-Square test was applied for highly significant ($p \leq 0,05$) and significant values ($p \leq 0,10$) (Littel *et al*., 2002). The degree of association among variables was analyzed by Pearson correlation coefficient (Steel and Torrie, 1985).

Results and Discussion

Botanical composition. Twenty seven species belonging to 14 families (table 1) were identified. The prevailing species was star grass (*C. nlemfuensis*), with presence in both treatments. From the total number of species 78 and 52 % were found in T1 and T2, respectively, and only 33 % was present in both treatments. A higher number of species was observed in the lowest parts of both enclosed pastures; nevertheless, such species as *Asclepias curassavica* and *Leucaena leucocephala* (regrowths) were located throughout the area of the enclosed pasture. Some species present considered non-desirable, such as *A. curassavica* and *Mimosa pudica*, are difficult to eradicate due to their continuous growth and reproduction (Villalobos and Arce, 2013).

Height and cover of the herbaceous stratum. The structural variables (table 2) were affected by the variation sources ($p \leq 0,05$) and by their interaction ($p \leq 0,01$), with the exception of height ($p > 0,05$). The largest height in T1 could have been due to the lower topographic position of the enclosed pasture where this treatment was located (fig. 1, table 2).

The pasture height is associated to biomass production and availability (Espinoza *et al*., 2001), from which it is derived that the variations in this indicator could modify defoliation patterns. The above-stated information was corroborated by Camacaro (2012) in a study with cattle that grazed heterogeneous vegetation communities, in which positive association was found (r: 0,75; $p \leq 0,01$) between consumption height and pasture height, as well as correlation between pasture height and dry matter (r: 0,37; $p \leq 0,01$), for which it is deduced that the latter had an effect on consumption height.

The low proportion of less desirable species (table 2) is possibly associated to the high competitive capacity of star grass. In this regard, Fernández *et al*. (1991) found that the height, cover and biomass production (kg DM/ha) of star grass are related to the rainfall regime of the zone (Aroa, Yaracuy state).

During the essay an inverse performance was observed between the cover of desirable species and the cover of the litter (table 2), which showed a negative association (table 3); this could be a product of the continuation of the growth of star grass and senescence in the rainy season and a higher accumulation of litter due to the low stocking rate.

Biomass production. The sources of variation and some of their interactions (table 4) were significant (p ≤ 0,05). The high significance of the treatment (table 4) and the low proportion of artificial shade suggest a topographical effect, because both enclosed pastures are located consecutively at

Table 1. Botanical composition of the enclosed pastures.

Common name	Species[1]	Family	T1	T2	Type[2]
Meona	*Acalypha alopecuroides*	*Acantaceae*	x		LD
Flor de Barinas	*Asclepias curassavica* L.	*Asclepiadaceae*	x	x	LD
Yuquilla	*Ruellia tuberosa* L.	*Asclepiadaceae*	x		LD
Algodón de seda	*Calotropis procera*	*Asclepiadaceae*		x	LD
Yerba de toro	*Pseudoelephantopus spicatus*	*Asteraceae*	x	x	LD
Escoba amarga	*Parthenium hyterophorus* L.	*Asteraceae*	x		LD
Corocillo	*Cyperusrotundus* L.	*Cyperaceae*	x		LD
Cruceta	*Eupatorium urticoides*	*Compositae*	x		LD
Palotal	*Vernonia pluvialis*	*Compositae*	x	x	LD
Cundeamor	*Momordica charantia*	*Cucurbitaceae*	x	x	LD
Lecherito	*Euphorbia heterophylla* L.	*Euphorbiaceae*		x	LD
Cola de gato	*Acalypha virginica*	*Euphorbiaceae*	x		LD
Bejuquillo	*Centrosema virginianum*	*Fabaceae*	x	x	D
Matarratón	*Gliricidia sepium*	*Fabaceae*	x		D
Pega pega	*Desmodium* sp.	*Fabaceae*		x	D
Leucaena	*Leucaena leucocephala*	*Fabaceae*	x	x	D
Dormidera	*Mimosa pudica*	*Fabaceae*		x	LD
Orore	*Pithecelobium caesalpinioides*	*Fabaceae*			MD
Molinillo	*Leonitis nepetaefolia* L.	*Lamiaceae*	x		LD
Escoba blanca	*Sida capirnofolia*	*Malvaceae*	x		LD
Guinea	*Megathyrsus maximus*	*Poaceae*	x	x	D
Star grass	*Cynodon nlemfuensis*	*Poaceae*	x	x	D
Falso Johnson	*Sorghum arundinaceum*	*Poaceae*	x		LD
Mapurite	*Roupala mollis*	*Proteaceae*	x		LD
Yerba mora	*Solanum nigrum* L.	*Solanaceae*		x	LD
Huevo de sapo	*Physalis angulata* L.	*Solanaceae*	x		LD
Cariaquito morao	*Lantana camara*	*Verbenaceae*	x	x	LD

[1]Pacheco and Pérez (1989), [2]CONABIO, (2014). D: desirable, LD: less desirable.

Table 2. Pasture height and cover.

Treatment	Height (cm)		Cover desirable species (%)		Cover less desirable species (%)		Cover litter (%)	
	T1	T2	T1	T2	T1	T2	T1	T2
Average	76,4[a]	61,1[b]	44,4[a]	43,4[b]	5,4[a]	4,3[b]	50,2[b]	52,3[a]
SD	16,5	16,4	23,8	23,4	4,4	3,6	24,0	23,5
Variation sources	**Probability**							
Treatment (T)	0,0005		0,0001		0,02		0,0001	
Sampling (M)	0,32		0,0001		0,0001		0,0001	
T x M	0,96		0,0001		0,0001		0,0001	

T1: grazing without shade, T2: grazing with shade.

Table 3. Correlation between pasture height and cover.

	Height	CD	CLD	CL
Height		0,5**	0,04[ns]	-0,44**
CD	0,5**		0,26[ns]	-0,99**
CLD	0,05[ns]	0,26[ns]		-0,43*
CL	-0,44**	-0,99**	-0,43*	

*$p \leq 0{,}05$; ** $p \leq 0{,}01$; NS: not significant, CD: cover desirable species, CLD: cover less desirable species, CL: cover litter.

Table 4. Production of biomass and its components.

Treatment	Variable (kg DM/ha)											
	LDM		STDM		SDM		LDDM		TDM		EDM	
	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2
Average	307[a]	208[b]	803[a]	536[b]	373[a]	245[b]	17[a]	15[b]	1 207,4[a]	751[b]	1110[a]	744[b]
SD	213	189	705	695	398	393	354	380	905	908	800	799
Variation source	Probability											
Treatment (T)	0,0002		0,0001		0,0002		0,0189		0,0001		0,0001	
Sampling (M)	0,0001		0,05		0,0002		0,0001		0,0005		0,0018	
Stratum (S)	0,0170		0,0001		0,0001		-		0,0001		0,0001	
T x M	0,255		0,0024		0,0186		-		0,0004		0,0065	
T x S	0,233		0,40		0,0008		-		0,37		0,72	
M x S	0,0001		0,04		0,0001		-		0,0007		0,0012	

*Different letters in the same row and for the same variable indicate significant differences. LDM: leaf DM, STDM: stem DM, SDM: senescent DM, LDDM: less desirable DM, TDM: total DM, EDM: edible DM.

the foot of the mountain. On the other hand, it was proven that during the experiment there was variation in the different variables of biomass production (table 4), due to the significance of the variation sources sampling and stratum ($p \leq 0{,}05$), besides the association among variables (table 5) with a possible effect on the defoliation patterns (Espinoza *et al*., 2001; Camacaro, 2012). Similar results regarding the stratum were reported by Alvarado (2000), who obtained that the DM production in the star grass with 23 to 30 days of regrowth was 55 % of leaves in the highest stratum and 37 % of leaves in the medium stratum.

The biomass production in this trial coincides with the one obtained by Espinoza *et al*. (2001) in *C. nlemfuensis* (1 100-1 166 kg DM/ha) in the Yaracuy state, with 21 days of resting during the rainy season (287 mm); but not with that obtained by Fernández *et al*. (1991) in the Lara state (734 kg/ha), also in the rainy sason (105,2 mm) but with resting of 40-60 days; from this it is inferred that the difference in biomass production is due to the edaphoclimatic and management conditions.

Selection of forage species. The most selected species was *C. nlemfuensis* (95 %) in both observation periods (table 6); the ewe lambs also selected in lower percentage other species (2,3 %): *L. leucocephala*, *Vermonia pluvialis*, *Solanum nigrum* L., *Lantana camara*, *Eupatorium urticoides* and *Megathyrsus maximus*. The first stratum was the one of higher preference, because of its accessibility in the vertical profile of the pasture and its higher biomass production. These results coincide with those reported by Espinoza *et al*. (2001) and Palma and Román (2008), who informed higher utilization of *C. nlemfuensis* and *L. leucocephala* as the height increased. The selection of a higher number of species occurred in the morning and in the enclosed pasture of T2 (table 6), in spite of its lower number of species (table 1).

The shade availability, with places of voluntary access of protection, and the thermoregulation mechanisms influence the selection and intake of forage species by the animals. During the study temperatures of 26 ºC and 32 ºC were recorded, at 9:00 a.m. and at 1:00 p.m., respectively. On the

Table 5. Correlations among biomass variables.

Variable	LDM	STDM	SDM	LDDM	TDM	EDM
SDM	0,36**		0,42**	0,17**	0,57**	0,58**
SDM	0,42**	0,79**		0,16**	0,76**	0,80**
LDDM	0,18^{ns}	0,25*	0,16^{ns}		0,57**	0,27**
TDM	0,57**	0,92**	0,76**	0,57**		0,96**
EDM	0,58**	0,97**	0,80**	0,27**	0,96**	

** $p \leq 0,01$; ns: not significant. LDM: leaf DM, STDM: stem DM, SDM: senescent DM, LDDM: less desirable DM, TDM: total DM, EDM: edible DM.

Table 6. Selected species per turn and per treatment.

Turn	Treatment	Selection per species (%)								
		1	2	3	4	5	6	7	8	OA
Ante-meridian**	T1	95			1		1			3
	T2	92	1	1		1		1	1	3
Past-meridian*	T1	99				1				
	T2	95	4		1					

*$p \leq 0,10$; ** $p \leq 0,05$; 1: *C. nlemfuensis,* 2: *L. leucocephala,* 3: *V. pluvialis,* 4: *S. nigrum* L., 5: *L. camara,* 6: *E. urticoides,* 7: *M. maximus,* 8: *P. spicatus*. OA: another activity (lying, standing, ruminating, urinating, walking).

other hand, Bondi (1989) stated that the heat increase that occurs in sheep because of digestion and metabolism is higher with protein-rich feedstuffs (54 %) than in carbohydrates (32 %) and lipids (29 %). The ewe lambs had lower body temperatures in the morning, as reported by Pinto-Santini *et al*. (2014), and the selection of species with different nutritional value was not a problem, in spite of the heat increase; on the other hand, the body welfare generated by the shade could have also been the cause of the higher number of selected species in T2.

Herrera (2012) reported, in works with grazing sheep under conditions of well drained savannas, a marked preference for the species of the *Poaceae*, *Fabaceae* and *Cyperaceae* families (42,86; 25,94 and 18,60 %, respectively). With regards to the consumed parts (table 7) in the ante-meridian hours the leaves averaged 96 %, the stems 2 % and another activity 2 %. In the past-meridian turn, the leaves averaged 70,5 % and the stems, 28,0 % (mean of the two treatments); from this it is proven that the ewe lambs required higher CP intake in the morning and higher energy intake in the afternoon, or that the seizing facility of the leaves due to their lower fiber content compared with the stems favored their selection. In that context, Chacón (2011) stated that the selection of the leaf is related to a high intake of nutrients, whose harvest by the animal would generate higher energy expense if it is intertwined between the stem biomass and the senescent material.

The stems of forage species, under tropical conditions and because of age, show higher fiber content, reduced digestibility and low crude protein levels (Fernández *et al*., 1991). For such reason, the animal reduces or increases the selection and consumption of stem depending on its nutrient needs;

Table 7. Parts of the plant consumed per turn and treatment.

Turn	Treatment	Consumed parts (%)		
		1	2	OA
Ante-meridian*	1	96	2	2
	2	96	1	2
Past-meridian*	1	56	44	
	2	85	15	

* $p \leq 0,01$. 1: leaves; 2: stems; OA: another activity (lying, standing, ruminating, urinating, walking).

such effects can increase due to the existence of variations in ambient temperature, which causes a status of discomfort in the animal (Araujo, 2005).

Regarding the species consumed in the enclosed pastures (table 6), the ewe lambs preferred to graze in the areas surrounding the water source, where the selected species were present in low proportions. This coincides with the reports by Hardoy and Danelón (1989) regarding the fact that under intensive grazing conditions, sheep and cattle use the available space in a non-uniform way and graze selectively, according to the location of water, land topography, climate, vegetation type and soil.

In all the evaluation periods it was observed that the ewe lambs, at certain times, consumed the herbaceous stratum of the area under artificial shade (T2) and/or used this area to remain lying and rest. The above-expressed fact can be considered a protection mechanism against climate factors, as proven by Arauz (2009), who reported a neutral environmental temperature for the ewe lamb between 13 and 31 ºC; this indicates that tropical areas are generally adverse for these animals.

The differential presence of species in the enclosed pastures assigned to T1 and T2, as well as the differences in height, cover and biomass production between treatments seems to be consequence of the topographical position of the enclosed pastures. The effect of the stratum on biomass production and the selection of species allow to infer the importance of structure in defoliation patterns. *C. nlemfuensis* was the most consumed species in both turns; nevertheless, the ewe lambs also selected, in lower proportion, other six species, which was observed mainly in the enclosed pasture of T2 and in the ante-meridian turn, although that enclosed pasture had less species than the paddock of T1.

It is concluded that the availability of artificial shade with voluntary access influenced the selection and intake of forage species for the ewe lambs, with preference for *C. nlemfuensis* and for the leaves. The differential selection of forage species and their parts, during the morning and afternoon turns, allows to infer that there were differences in the nutritional needs of the ewe lambs during the day; this could also be associated with the climate elements that modify such requirement.

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