Scientific Paper

Floristic composition and nutritional quality of a meadow grazed by sheep in the dry Colombian Caribbean

Clara Viviana Rúa-Bustamante[1] https://orcid.org/0000-0003-0791-4406, Juan Ricardo Zambrano-Ortiz[1] https://orcid.org/0000-0003-3748-6211, Adelina Rosa Caballero-López[1] https://orcid.org/0000-0001-8601-6713 and Leyla **Ríos-de-Álvarez**[2] https://orcid.org/0000-0003-4211-7023

[1]*Corporación Colombiana de Investigación Agropecuaria AGROSAVIA, CI Motilonia. Agustín Codazzi, Cesar, Colombia.* [2]*Department of Animal and Dairy Sciences. Mississippi State University. Box 9815. Mississippi State, MS 39762, USA. E-mail: crua@agrosavia.co, jzambrano@agrosavia.co, acaballerol@agrosavia.co, leyla.rios@msstate.edu*

Abstract

Objective: To evaluate the floristic composition and nutritional quality of a meadow used for grazing of hair sheep under the agroecological conditions of the dry Colombian Caribbean.

Material and Methods: The study was conducted at the Motilonia Research Center, of the Colombian Corporation of Agricultural Research AGROSAVIA. Curves of species accumulation and abundance range were made for the data analysis through the statistical program Qeco, as well as the Student's t-test for independent samples with Infostat.

Results: Thirteen plant species were recorded in the meadow, 12 were identified at species level and one at genus level. The representation, in terms of family was given by *Poaceae* (30,8 %), *Fabaceae* (30,8 %), *Cyperaceae* (7,7 %), *Boraginaceae* (7,7 %), *Portulacaceae* (7,7 %), *Apocynaceae* (7,7 %), and *Amaranthaceae* (7,7 %). The floristic composition in the entire meadow (control transect) was different, in terms of number of species with regards to the feeding sites of the flock ($p = 0,0249$). This proves that the animal made a preliminary selection of the forage.

Conclusions: Thirteen plant species were recorded in the meadow and 12 were identified at species level. In this study, the applied methodology for the determination of the floristic composition of the meadow, with the use of the transects and the cross, was accurate for the identification of the dominant species in the enclosed pastures *versus* those that were most visited by the animals.

Keywords: botanical composition, sheep, nutritive value

Introduction

The study of the floristic composition of the grazing areas allows to know the variety of available species for the animals and the correct balance of beneficial plants to increase the flock productivity. In the Colombian Caribbean, continuous or extensive grazing has been identified as main feeding system for hair sheep (Rúa-Bustamante, 2018; Mestra-Vargas *et al*., 2020). In a recent study conducted by Mestra-Vargas *et al*. (2020) it was reported that 69,2 % of the production systems used *Bothriochloa pertusa* (L) A. Camus (colosuana) under continuous grazing; while 19,2 % utilized *Megathyrsus maximus* (Jacq.) B.K. Simon & S.W.L. Jacobs (guinea).

It is also known that in the Caribbean region, *B. pertusa* is one of the most established grasses in animal husbandry systems (Mojica-Rodríguez and Burbano-Erazo, 2020). However, there are no studies that identify in detail the species present in the enclosed pastures, and those utilized by the grazing animals, so that the ones that are preferred by them can be known. Thus, the objective of this study was to evaluate the floristic composition and nutritional quality of a meadow used for hair sheep grazing under the agroecological conditions of the dry Colombian Caribbean.

Materials and Methods

Location of the study. The study was conducted at the Motilonia Research Center, of the Colombian Corporation of Agricultural Research AGROSAVIA, located at 10º 0' 7" North latitude and 73º 14' 51" West longitude, in the Agustín Codazzi municipality, Cesar Valley micro-region of the Cesar Department. The zone is at 102 m.a.s.l., shows annual average temperature of 28,7 ºC, relative humidity of 70 % and annual rainfall of 1 600 mm, with bimodal distribution from May to June and from September to December (data of the meteorological station of the Institute of Hydrology, Meteorology and Environmental Studies IDEAM, of the Motilonia Research Center). The study area corresponded to one hectare of improved meadow, with predominance of pasture *M. maximus* cv. Tanzania, previously established (two to three years), with resting period between 25

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and 28 days, and occupation between three and six days, according to the season (rainy and dry season, respectively). The animals grazed, approximately, during 8 h per day, with night enclosure of more than 12 h.

Floristic composition and feeding sites of the flock. The floristic composition of the meadow was analyzed at a single moment through the adaptation of the methodology proposed by Velásquez-Vélez *et al*. (2009). This methodology allows to analyze the composition of the vegetation in two types of transects: one randomly distributed in the enclosed pasture, representative of what is available throughout the grazing area (control transect), and another one defined by the path made by the animals to obtain feed (animal transect). Before starting the evaluations, an adaptation period of seven days was developed, for the animals and the observers.

In the meadow five lineal transects of 50 m (control transects) were outlined to sample the floristic composition with the utilization of a cross-shaped instrument (Ospina *et al*., 2009). It consists in the union of two wooden pieces with one meter of length, perpendicularly overlapped (fig. 1). To determine the animal transects, observations were made of the flock during the grazing hours. Thus, the most frequented sites by the animals were identified, and then five random points were selected to outline lineal transects of 50 m (animal transects) and evaluate the floristic composition with the cross.

In both transects, the cross piece was placed every 1,5 m, recording the plant specimens (herbaceous or tree ones) touched by the tips of the arms. That is, four records were generated per cross placing, 136 per transect (50 m) and 680 observations in the entire control transect and animal transect. This evaluation of the meadow was conducted in May, 2018 (rainy season), which corresponded to the sixth month of the study of continuous grazing of the experimental group of male hair sheep, in growing and fattening stage.

The found plants were taxonomically identified through consultation with experts and revision of taxonomic keys. The species were classified into consumed or not consumed by livestock. For such purpose the traditional use they have in the region and the consulted secondary information were considered.

Nutritional analysis of representative plant species. With the information of the floristic composition obtained in the animal transect, samples of the three most representative plants were taken, which were sent to the laboratory of analytical chemistry of the Tibaitatá Research Center of AGROSAVIA, for the analysis of nutritional composition through the near infrared spectroscopy (NIRS).

Statistical analysis. To analyze the floristic composition matrices based on the abundance of individuals were organized, and a curve of species accumulation was constructed to value diversity in terms of meadow richness (control transect), as well as the sampling effort developed for the evaluation of the vegetation. The accumulation curves were elaborated through an interpolation and extrapolation process using the program Qeco (Di Rienzo *et al*., 2010), which uses a routine of the Vegan library (Oksanen *et al*., 2013), compiled in the program R.

Range and abundance curves were also elaborated for the control and animal transects, in order to compare the available forage offer in the meadow *versus* the edible potentials by the animals. In addition, a Student's t-test for independent samples was applied, aiming at checking the differences in number of species in the transects. The range and abundance curves were constructed through the free program Qeco (Caballero-López, 2019), and the Student's t-test for independent samples by means of Infostat (Di Rienzo *et al*., 2018).

Results and Discussion

Floristic composition. Thirteen plant species were recorded in the meadow, 12 were identified at species level, and one at genus level. The representation in terms of family was given by *Poaceae* (30,8 %), *Fabaceae* (30,8 %), *Cyperaceae* (7,7 %), *Boraginacea* (7,7 %), *Portulacaceae* (7,7 %), *Apocynaceae* (7,7 %) and *Amaranthaceae* (7,7 %). Nevertheless, when considering the number of sampled individuals, the families with higher representation of individuals in the meadow were *Poaceae* (56,2 %), *Cyperaceae* (26,3 %) and *Fabaceae* (14,4 %). The obtained results are similar to the ones reported in well-drained savannas, grazed by sheep in Venezuela, where species of the families Poaceae and Cyperaceae prevailed (Morantes *et al*., 2017).

The accumulation curve (fig. 1) showed that the quantity of samples to evaluate the floristic composition in the meadow was adequate, because the curve reaches the asymptote and indicates that the number of recorded individuals was sufficient to cover the plant richness of the meadow at the sampling moment. The above-explained fact is also indicative of the little diversity present in the meadows established with cultivated pastures, such

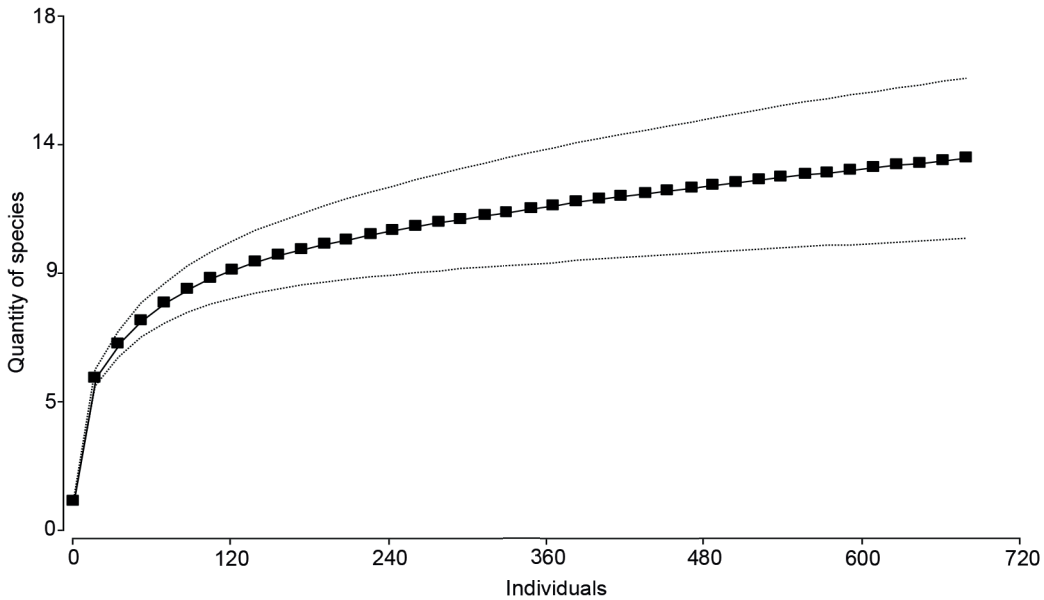

Figure 1. Accumulation of species based on individuals of the meadow
The thin dotted lines represent the confidence intervals at 95 %.

as *M. maximus*, which are conventionally managed. Similar results were reported by Gálvez-Cerón *et al.* (2014) in enclosed pastures located in the tropical dry forest of the Nariño Department (Colombia), who found 13 species, the family Poaceae being the one of higher dominance (more than 60 %). From it, *Panicum maximun* (now *M. maximus*) contributed with 44 % of the sampled individuals.

The range and abundance curve for the control and animal transect (fig. 2) reflects the dominance of few species in the meadow. *M. maximus* cv. Tanzania showed the highest number of individuals, followed by *Cyperus rotundus* L. and *B.* pertusa, both with approximately half the number of individuals compared with the first one. The high presence of *C. rotundus* can be related to the degradation of the meadow, because in spite of the tall habit and cover easiness of *M. maximus* cv. Tanzania, Cyperaceae family has morphological characteristics that give it high capacity of competition for nutrients (Labrada *et al.,* 1996). Nevertheless, some authors refer the properties of *C. rotundus* for feeding cattle (Fernández-Mayer, 2020) and sheep (Gómez-Mesa *et al.,* 2014). In addition, in a study conducted in Venezuela, an appearance frequency of Cyperaceae of 8 % in feces of grazing sheep was reported, which indicates that these species can be selected as a small proportion of the diet (Morantes *et al*., 2017).

The range and abundance curve also shows that only seven of the 13 species available in the enclosed pasture were found in the feeding sites of the flock. Three were classified as Poaceae and three, Fabaceae; that is, 85,6 % of the taxa belong to two botanical families. The research conducted by Galeano *et al*. (2013), developed in six municipalities of South Tolima (Colombia), characterized the floristic composition of the sheep grazing zones with the companionship of farmers. In this study an important contribution of these two families to small ruminant feeding was reported, because from the 46 referenced species of frequent intake, 26,5 and 16,3 % were from the families *Fabaceae* and *Poaceae*, respectively.

In terms of abundance, the three *Poaceae* species represented 2 % of the offer, which can affect the stability and resilience of the agroecosystem. In this regard, some studies indicate that there is relation between the richness and temporary stability of pastureland production. This is associated to the fact that a higher number of species contributes a broader set of adaptive traits (Ospina *et al*., 2012).

The Student's t-test for independent samples (table 1), applied for the control and animal transect, showed statistical differences (p = 0,0249), by indicating that the species diversity (control transect) was significantly higher than the number of species visited by the animals in their habitual route.

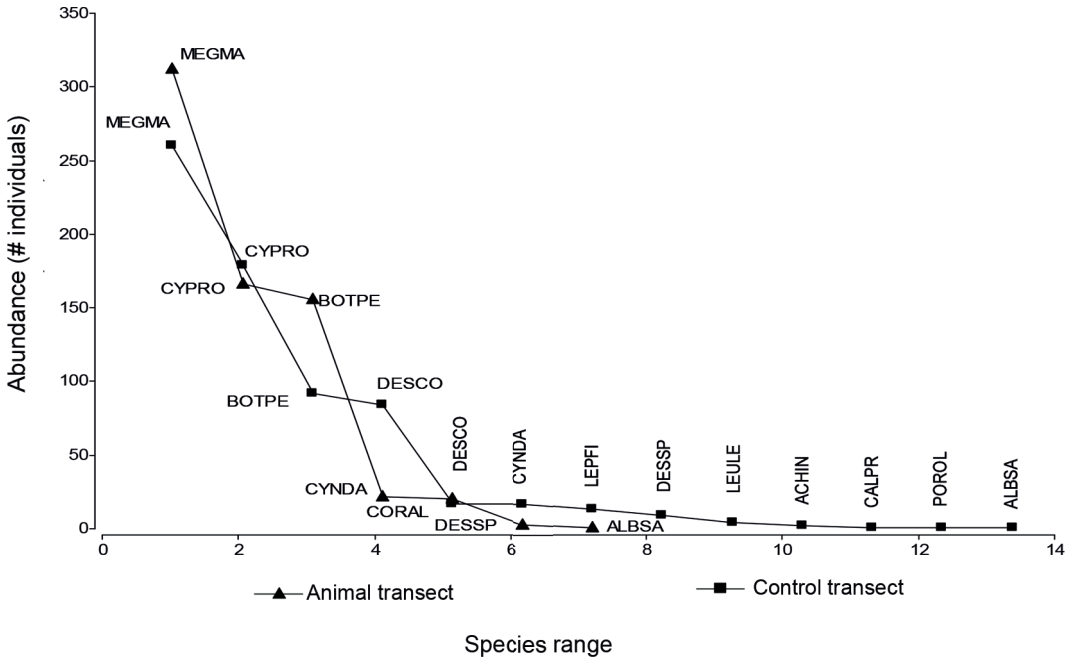

Figure 2. Species range and abundance
MEGMA (*M. maximus* cv. Tanzania), CYPRO (*C. rotundus*), BOTPE (*B. pertusa*), CYNDA (*Cynodon dactylon* (L.) Pers), LEPFI (*Leptochloa filiformis* (Lam.) Beauv), DESCO (*Desmodium scorpiurus* (Sw.) Desv), ACHIN (*Achyranthes indica* (L.) Mill), ALBSA (*Albizia saman* (Jacq.) Merr), LEULE (*Leucaena leucocephala* (Lam.) de Wit), CORAL (*Cordia alba* (Jacq.) Roem. & Schult), POROL (*Portulaca oleracea* (L.), CALPR (*Calotropis procera* (Aiton) Dryand), DESSP (*Desmodium* spp)

Table 1. Results of the Student's t-test for number of species in the control and animal transect.

	Animal transect	Control transect
n	5	5
Mean	4,00	6,40
t	-2,75	
P - value	0,02	

$p < 0,05$ is statistically significant

This can be influenced by the characteristics of the plants and animals, the forage availability, diet composition, season, among other factors (Wentzel and Alonso, 2020).

According to the traditional use they receive in the region or taking into consideration secondary information, livestock intake was recorded in 11 of the 13 species found in the meadow. With regards to the seven species recorded in the feeding sites of the flock, all of them have references of intake by the animals (table 2).

Although the enclosed pastures established with cultivated pastures show trend to be less diverse, the number of species with intake record reflects the potential of local herbaceous and non-herbaceous resources for animal feeding. The latter is important because it can provide a stable and balanced forage offer throughout the year (Romero and Duarte, 2012).

Nutritional analysis of representative plant species. Table 3 shows the nutritional composition of dominant plant species in the meadow. A CP level of 9,8 % was found for the prevailing forage *M. maximus* cv. Tanzania.

The DM content of the dominant species in the meadow was 37,3; 49,9 and 34,5 % for *M. maximus* cv. Tanzania, *B. pertusa* and *C. rotundus,* respectively. For *B. pertusa*, the results were higher than those reported by Roncallo-Fandiño *et al*. (2020), who under these same agroclimatic

Table 2. Categorization of plant species found in the meadow (control transect) *versus* animal transect and their intake potential.

Family	Species	Presence animal transect	Intake	Source
Poaceae	*M. maximus*	Yes	Yes	Patiño-Pardo *et al*. (2018) traditional use¥
	B. pertusa	Yes	Yes	Tapia-Coronado *et al*. (2019) traditional use¥
	C. dactylon	Yes	Yes	Fernández-Mayer (2020)
	L. filiformis	No	No	
Fabaceae	*D. scorpiurus*	Yes	Yes	Heuzé *et al*. (2018) traditional use¥
	Desmodium spp.	Yes	Yes	Traditional use¥
	A. saman	Yes	Yes	Palma-García and González-Rebeles-Islas (2018); traditional use¥
	L. leucocephala	No	Yes	Hernández-Hernández *et al*. (2020); traditional use¥
Cyperaceae	*C. rotundus*	Yes	Yes	Fernández-Mayer (2020)
Apocynaceae	*C. procera*	No	Yes	Adama *et al*. (2017)
Boraginacea	*C. alba*	No	Yes	Palma-García and González-Rebeles-Islas (2018) traditional use¥
Amaranthaceae	*A. indica*	No	No	Palma-García and González-Rebeles-Islas (2018) traditional use¥
Portulacaceae	*P. oleracea*	No	Yes	Sarmiento-Franco *et al*. (2016)

Traditional use makes reference to the species that are acknowledged in the region for being consumed by livestock (sheep and cattle)

Table 3. Nutritional composition of the main forages found in the evaluated meadow.

Species	DM	CP	NDF	ADF	EE	IVDMD	TT, g kg^{-1} DM Eq Tannic acid	CE	NEg Ruminants
	g 100 g^{-1} MS							Mcal kg^{-1} DM	
M. maximus cv. *Tanzania*	37,3	9,9	66,8	36,0	1,7	56,0	10,7	4,1	0,4
B. pertusa	49,9	8,0	67,3	40,7	1,9	53,1	9,6	4,0	0,3
C. rotundus	34,5	15,2	53,9	27,6	1,5	63,0	17,1	4,1	0,7

DM: Total dry matter, CP: Crude protein, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, EE: Ethereal extract, TT: Total tannins, IVDMD: Dry matter digestibility, CE: Crude energy, NEgRuminants: Net energy of gain ruminants

conditions found as average 37,8 % of DM in the dry season. In this type of forages, it has been identified that, at higher time of harvest, higher DM content, which can influence negatively the CP content. Thus, the lowest value (8,0 % of CP) is recorded for *B. pertusa* in this study.

The species *C. rotundus* reached the highest CP content (15,2 %), result that is similar to the one reported by Petruzzi *et al*. (2003), who found a content of 14,2 % of crude protein for this species. *M. maximus* cv. Tanzania had crude protein content of 9,8 %, lower value than that reported by Mojica-Rodríguez and Burbano-Erazo (2020) (13,6 %) and the one referred by Patiño-Pardo *et al*. (2018) and Cornejo-Cedeño *et al*. (2019), who indicated for the cultivar Tanzania (25 days of regrowth) crude protein content between 12,0 and 13,0 %, respectively. These results can be associated to the soil fertility and to meadow management labors, besides the regrowth age, and season in which it is harvested.

The NDF and ADF contents were lower for the species *C. rotundus* (53,9 % and 27,6 %, respectively), compared with *M. maximus* cv. Tanzania (66,76 % and 36,03 %) and *B. pertusa* (67,3 and 40,7 %). The NDF values are related to the digestibility of forages (Jones and Siciliano-Jones, 2016). In the obtained results, *C. rotundus* showed the highest digestibility percentage (63,0), followed by *M. maximus* cv. Tanzania (56,0) and *B. pertusa* (53,0).

The highest content of total tannins (TT) was shown by the species *C. rotundus* 17,1 (g kg^{-1} DM Eq tannic acid). Tannins are compounds that are

considered anitinutritional factors (Mueller-Harvey, 2006). When they appear in high levels, they can cause unfavorable effects on the digestive process (González-Mateos *et al*., 2019), and contribute to the decrease of intake by the animals. On the contrary, when they are adequately consumed they can have positive effects for the animals.

The nutritional content of forages is closely related to the management of the meadow and to soil quality or fertility, and can influence positively or negatively the intake by the animal, for which accompanying the botanical composition studies of the meadow with research about palatability and selectiveness is suggested.

Conclusions

Thirteen plant species were recorded in the meadow and 12 were identified at species level. The most prevailing plant species in the evaluated meadow were *M. maximus* cv. Tanzania, *B. pertusa* and *C. rotundus*. In this study, the methodology applied for the determination of the floristic composition of the meadow, with the use of the transects and the cross, was accurate for the identification of the prevailing species in the enclosed pastures versus those most visited by the animals. In future studies it is important to evaluate the perennial character of the species, and determine the selection of the animals per season through micro-histological techniques.

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Conflict of interests

The authors declare that there is no conflict of interests among them.

Authors' contribution

- Clara Viviana Rúa-Bustamante. Conception, design of the study, data obtainment, data processing, analysis and interpretation, manuscript writing and revision.
- Juan Ricardo Zambrano-Ortiz. Data obtainment, data processing, interpretation of results, bibliographic review and manuscript writing.
- Adelina Rosa Caballero-López. Data analysis, interpretation of results, bibliographic review and manuscript writing.
- Leyla Ríos-de-Álvarez. Interpretation of results, bibliographic review and manuscript writing and revision.

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