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Phytosociological Surveys and Monitoring of the Bromatological Parameters According to the Age of Regrowth of Savannah Pastures Perfectly Reconstituted in the Central Zone of Côte d'Ivoire

Gouagoua Séverin Kouadja[1], Adam Camille Kouamé[1*], Kouakou Eugène Kouadio[1], Brou Jean Kouao[1] and N'Gouan Cyrille Kouassi[1]

[1]Program of Animal Production, National Centre for Agricultural Research (CNRA), Bouaké Regional Office, P.O. box 633 Bouaké 01, Bouaké, Côte d'Ivoire.

Authors' contributions

This work was carried out in collaboration among all authors. Author GSK is the principal investigator of this research. Author GSK was responsible for the collection of samples and contributed to the chemical analyses. Author Adam Camille KOUAMÉ contributed to the analyses and writing of the Manuscript. Author NCK participated in the design of the study. Author BJK was responsible for the formulation of the research question and reviewed the manuscript. Author KE reviewed the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Although pastures in central (Affouvansou) Côte d'Ivoire are abundant, signs of undernutrition are observed in the animals towards the end of wintering, possibly due to insufficient quality pastures, poor grass quality, or poor herd distribution. Using the in-vivo digestibility method, bromatological monitoring of the fodder from these pastures was carried out according to the development age of the regrowth using Djallonke sheep. The objective is to help in the judicious use of these pastures. At regrowth age intervals between the 4th and 8th week, the nitrogen content in the grass decreases, the energy value increases at 6 weeks, and decreases slightly to remain at a correct value in the following weeks. Due to its nitrogen value, this pasture can be classified as a more or

**Corresponding author: Email: kadamcamille@gmail.com;*

less poor quality savannah fodder. However, the savannah studied is of excellent quality from an energy point of view at 5 - 6 weeks of regrowth age. Depending on the nitrogen value, the forage can be said to be of average quality from the 5th to the 7th week. Beyond 8 weeks, the forage is of poor quality. The nitrogen content is therefore a limiting factor here. It cannot meet the maintenance needs of the UBT. It, makes sense to use the pastures in the center of the country between the 6th and 7th week of regrowth to get the most out of it.

Keywords: Bromatology; fallow land; savannah; pastures; Cote d'Ivoire.

1. INTRODUCTION

Côte d'Ivoire has about 11 million hectares of rangelands or 34% of the country's surface area [1]. It is a country that essentially shares the humid forest environment in the south and the savannah environment in the center and north (moderately dry). In the savannah areas with low human density, the pressure on land for crops is light, and perfectly reconstituted savannahs dominate. In areas with high human density, the frequency of land recultivation is high, and fallow land dominates [1-2]. Here, as in most states of the sub-region, savannah grazing remains the basis of ruminant feeding [3]. These are large expanses of land that are little or no exploited during the rainy season, where natural sources of fodder seem inexhaustible. Despite this, the loss of weight of livestock is observed especially towards the end of wintering (rainy season). Reasons for this include poor digestibility of the grass and an excessive drop in fodder quality due to excessive lignification, insufficient dry matter intake due to excessive stocking, or poor herd distribution [4]. All these factors occur simultaneously and it is difficult to specify the probable cause of animal undernutrition. The establishment of artificial pastures could be a means to a solution. Unfortunately, the farmers, who are generally illiterate, do not yet understand the techniques for installing and managing artificial pastures, particularly in the locality of Affouvansou in the central part of the country. So fallow land and spontaneous grasses grow there to replace the fodder soil. Judicious management of these grassland formations is necessary to optimize their production and thus reduce the effects of malnutrition in livestock. For this to happen, it was important in this study to provide information on the floristic composition and to monitor the evolution of the chemical composition and nutritional characteristics of the regrowth's of different savannah formations according to their development ages in order to make the most of it.

2. MATERIALS AND METHODS

2.1 Materials

Trials were conducted with six (6) castrated Djallonke sheep weighing between 23 and 33 kg. The average age of these animals was 29 months. These sheep wore cloth pants to prevent contamination of faeces with urine. In addition, they were provided with water and licking stones at will. A perfectly reconstituted savannah was used as pasture. It was a grassy savannah pasture put in defense in the pastoral zone of Affouvansou. This zone is located near the town of Bouake in central Côte d'Ivoire (Fig. 1). The plot in question has not been cultivated for about twenty years, but it has been subject to regular bush fires every year. This grassland was composed of grass species characteristic of the reconstituted savannah [2].The study area is a transition between savannah and forest. It is located in the centre of Côte d'Ivoire and is characterised by clear forest vegetation, a Sudano-Guinean climate with an average annual rainfall of 1000 mm. The temperature varies between 22°C and 37°C. This central zone has a vast plateau relief with an altitude varying between 200 and 500 m. The savannah transition zone comprises two administrative regions, the Aries region, and the Gbêkê region.

2.2 Methodology

2.2.1 Phytosociological surveys

In this locality, the phytosociological surveys were carried out using the classic stigmatist method of Braun-Blanquet [5] in square plots (2 to 4 plots) of 625 m^2 (25 m x 25 m). Three surveys were conducted. This method consists of making a list of the plants present in a representative and homogeneous sample, by placing two markers linked by a 10 m string graduated every 10 cm. Each graduation constitutes a reading point. Along this string, a thin metal rod is placed perpendicular to the ground and descends to the ground. All herbaceous species that come into contact with the stem have been recorded. Several species could be noted at the same reading point, but each species was recorded only once (Fig. 2). Plant species that were not identified in the field were collected, codified, and sent to the National Floristic Centre of the Félix Houphouet-Boigny University of Abidjan to be identified with the National Reference Herbarium.

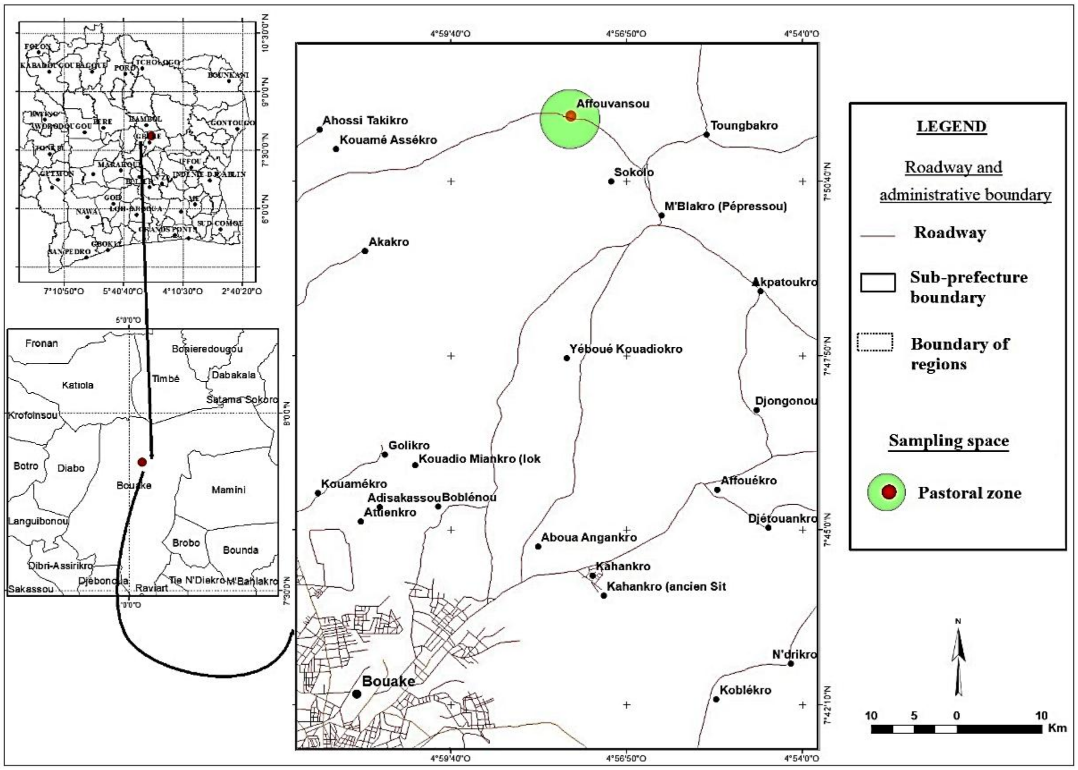

Fig. 1. Location of the floristic survey and data collection area

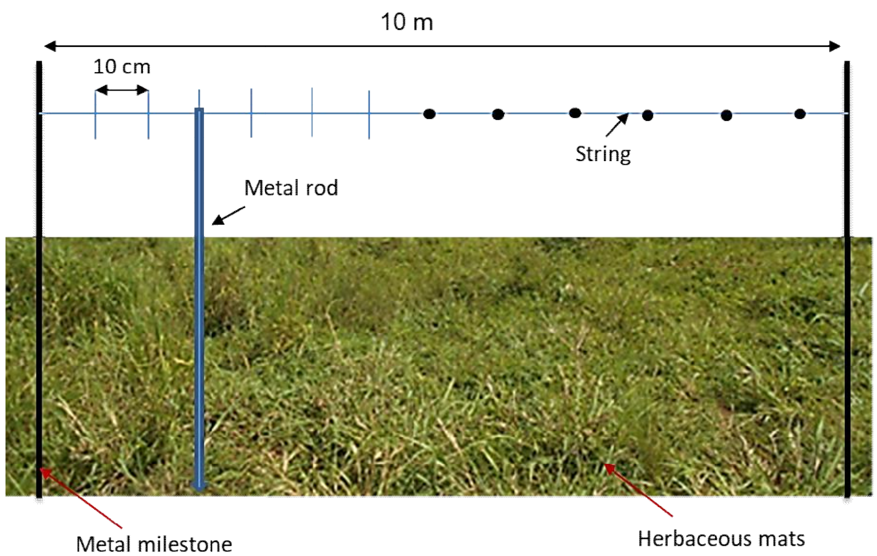

Fig. 2. Schematic description of the floristic survey

2.2.2 Field trial implementation

The field trial was conducted over six months (January to July 2012) at Affouvansou. A preliminary regularisation cut of the herbaceous canopy was carried out before the study, introducing a high instantaneous load on the plot with the help of bullfrogs. Regularisation grazing by the animals has a double advantage. On the one hand, it makes it possible to determine the plant species grazed by the animals under the conditions of intensive exploitation of this savannah. On the other hand, the regrowth that follows the passage of the animals is all of the same age, which allows a more rational study of the evolution of the bromatological value of the species eaten according to their age.

The regrowth that followed this regularisation cut was mowed each morning with a sickle, mechanically chopped into 4 to 5 cm strands, and distributed in green to the 6 sheep in digestibility cages. The amount of feed placed in the feeders was weighed before being distributed. Each animal was considered as a repeat. The study began when the regrowth was two weeks old. Thus, after a one-week adaptation period, the actual measurements began at week 4 and ended at week 8. Each result related to a sample that corresponded to the forage offered during one week. The offered and refused quantities and the quantities of feces were weighed for 6 days within each week (Monday to Saturday).

Each morning, the grass was cut and distributed in two meals spaced 7 hours apart, with the first meal at 9 a.m. after the refusals were withdrawn and the second at 4 p.m. The refusals were taken each morning before the distribution of the first meal of the day. The feces were kept in individual plastic buckets in a cold room. At the end of each week, the total amount of feces from each animal was weighed. Aliquots of individual faeces and fodder offered and refused were dried in an oven at 105°C for 24 hours to estimate the dry matter (DM) content. After homogeneous mixing, followed by grinding, the mixture was also used as a sample (100 g) for bromatological analysis, according to the methods described by Naumann and Bassler [6].

2.2.3 Bromatological analyses

After drying 100 g of samples (faeces, offered and rejected fodder) in an oven at 105°C for 24 hours, the dry matter (DM) content was determined by weighing. The determination of the mineral matter (MM) was made by weighing before and after total incineration of the sample at 550°C. The organic matter (OM) was deducted (OM = 1000 - MM). The crude cellulose (CC) was determined after successive attacks on the sample with 0.26 N sulphuric acid and then with a 0.23 N hot potash solution. The nitrogenous matter (N x 6.25) was obtained by mineralisation of the sample with concentrated sulphuric acid in hot Kjeldahl flasks, distillation and nitrogen titration. The fat was obtained by extraction with petroleum ether using the Soxhlet apparatus. Gross energy, digestible energy (DE), metabolisable energy (ME), net energy content (NE) and values for true protein (excluding non-protein nitrogen) actually digestible in the gut (PDI) were calculated from regression equations established by INRA [7].

2.2.4 *In vivo* digestibility

Digestibility was assessed by calculating the apparent digestibility coefficient (CUDa) of the dry matter, organic matter (OM) and nitrogenous matter of the forage was calculated using the following formula:

CUDa (%) = (DM ingested - DM excreted) x 100 / DM ingested

2.3 Analysis of the data

The parameters were evaluated from inventory data. These data were subjected to an analysis of variance and a Student - Newman - Keuls test at the 5% threshold (NESTED-SAS procedure, SAS Institute Inc.). These include the floristic richness and their specific contribution, the nutritional characteristics of savannah fallow regrowth and their energy values.

3. RESULTS

3.1 Phytosociological Composition

A total of 19 species have been identified. They are divided into 15 genera belonging to 9 botanical families (Table 1). The family *Poaceae*, which is better represented, constitutes 93.95% of the total flora with seven (07) species. The main species encountered are, *Hyparrhenia smithiana* (Hook.f.) Stapf (Poaceae), *Hyperthelia dissoluta* (Nees) Clayton (Poaceae), *Hyparrhenia subplumosa* Stapf (Poaceae), *Digitaria delicatula* Stapf (Poaceae), *Andropogon gayanus* Kunth (Poaceae), *Eragrostis turgida* (Schumach.) De

Table 1. Phytosociology of the pastoral zone of affouvansou in the centre of Côte d'Ivoire

Species	Families	Specific contribution (%)
Perennial grasses		
Hyparrhenia smithiana (Hook.f.) Stapf	*Poaceae*	36,28
Hyparrhenia subplumosa Stapf	*Poaceae*	16,51
Hyperthelia dissoluta (Nees) Clayton	*Poaceae*	28,60
Andropogon gayanus Kunth	*Poaceae*	5,35
Andropogon ascinodis C.B. Clarke	*Poaceae*	0,47
Annual grasses		
Digitaria delicatula Stapf	*Poaceae*	5,81
Eragrostisturgida (Schumach.) De Wild.	*Poaceae*	0,93
Cyperacees		
Fimbristylis pilosa Vahl	*Cyperaceae*	0,93
Fimbristylis sp.	*Cyperaceae*	0,23
Mariscus alternifolius Auct.	*Cyperaceae*	0,47
Cyperus tenuiculmis Boeckeler	*Cyperaceae*	0,23
Fodder legumes.		
Zornia glochidiata Rchb. ex. DC.	*Fabaceae*	0,47
Vigna reticulata Hook.f.	*Fabaceae*	0,23
Other plants		
Spermacoce scabrida Pohl ex DC.	*Rubiaceae*	0,93
*Sonchus elliotianus*Hiern	*Asteraceae*	0,70
Curculigopilosa(Schumach. &Thonn.) Engl.	*Hypoxidaceae*	0,23
Polygala arenaria Willd.	*Polygalaceae*	0,23
Woody plants		
Parinari curatellifolia Planch. Ex Benth.	*Chrysobalanaceae*	0,70
Trichilia emetica Vahl	*Meliaceae*	0,70
TOTAL		**100**

Wild (Poaceae), *Andropogon ascinodis* C.B. Clarke (*Poaceae*). The list of these plants has been corrected using Plantlist (http://www.plantlist.org/tpl1.1/search).

3.2 Bromatological Composition

During the 5 weeks of the study, the dry matter content of the regrowth increased from 25.0% to 36.20%. Only the macroelements calcium and phosphorus could be dosed. Thus, the calcium contents do not vary greatly and are as follows: 4.2 g; 4.6 g; 4.1 g; 4.3 g and 4.8 g/kg DM, depending on the week. Similarly, the phosphorus content did not vary and remained equal to 1.9 g/kg DM during the grass study period. Total Nitrogen Matter (TNM) increased from 89 g to 62 g/kg DM from the 4th to the 8th week of regrowth age. Crude Cellulose (CC) content increased from 327 to 334 during the same study period (Table 2).

3.3 Nutrient Digestibility

The dry matter (DM) digestibility of grass is 45.0% at 4 weeks. It increased by 9 points at week 5 (54.7%) and then remained virtually unchanged at this value over the following weeks. Organic matter (OM) behaved similarly. From 55.3% at week 4, its digestibility coefficient increased by 9 points (64.2%) at week 5, before remaining at this level during the following weeks. For total nitrogen matter, digestibility is higher at 6 weeks (59.1). The lowest value (50.5) is at 4 weeks of regrowth age (Table 2).

3.4 Energy Value

The metabolizable energy (ME) content is high in the 6-week old grass (2104 kcal/kg DM). Its lowest value is obtained at 4 weeks (1772 kcal/kg DM). The net energy value of the forage is as follows: 0.58 UFL (Milk Fodder Unit) and 0.48 UFV (Meat Fodder Unit); 0.70 UFL and 0.62 UFV; 0.71 UFL and 0.63 UFV; 0.64 UFL and 0.54 UFV; 0.64 UFL and 0.55 UFV at 4, 5, 6, 7 and 8 weeks respectively (Table 2). The UFL content of the 6th and 5th weeks are not significantly different ($P > 0.05$) between them. The same is true of those at weeks 7 and 8. However, the values observed at weeks 6 and 5 are significantly different ($P < 0.05$) from those

Table 2. Nutritional characteristics of perfectly reconstituted savannah regrowth in the pastoral zone of Affouvansou

Parameters	Units	Age of regrowth (weeks)				
		4	5	6	7	8
Dry matter	%	25,00	27,40	29,60	32,0	36,20
Minerals						
Ash	**%**	120	109	105	97	96
Calcium	**%**	4,2	4,6	4,1	4,3	4,8
Phosphorus	**%**	1,9	1,9	1,9	1,9	1,9
Organic compounds						
Organic matter	**g/kg DM**	850	891	895	903	904
Crude cellulose	**g/kg DM**	327	328	328	330	334
Nitrogen Matter	**g/kg DM**	89	77	75	66	62
Nutrient digestibility						
Dry matter	**%**	45,0	54,7	54,6	56,6	54,6
Organic matter	**%**	55,3	64,2	64,2	58,7	59,2
Nitrogen Matter	**%**	50,5	53,8	59,1	57,7	58,8
Energy value						
Gross energy	**Kcal/kg DM**	4207	4233	4247	4285	4274
Digestible energy	**Kcal/kg**	2188	2582	2598	2376	2391
Metabolisable energy	**Kcal/kg**	1772	2091	2104	1925	1937
Net energy	**UFL**	0,58	0,70	0,71	0,64	0,64
	UFV	0,48	0,62	0,63	0,54	0,64
Nitrogen value		4	5	6	7	8
Digestible nitrogenous materials	**g/kg DM**	45	41	44	38	36
PDI values	**PDIE**(g/kg MS)	67	70	69	63	63
	PDIN(g/kg MS)	57	50	48	42	44

MM: Mineral matter; Ca: Calcium; P: Potassium; Na: Sodium; OM: Organic matter; CC: Crude cellulose; MAT: Total nitrogenous matter; DM: Dry matter; DE: Digestible energy; ME: Metabolisable energy; UFV: Meat fodder unit; UFL: Milk fodder unit, PDIE: Digestible protein in the intestine allowed by energy; PDIN: Digestible protein in the intestine allowed by nitrogen

Table 3. Comparison of the UFL values obtained

Age of regrowth (weeks)	UFL (Mean ± standard deviation)
4^{th} week	0.58 ± 0.03^{c}
5^{th} week	0.70 ± 0.03^{a}
6^{th} week	0.71 ± 0.06^{a}
7^{th} week	0.64 ± 0.04^{b}
8^{th} week	0.64 ± 0.05^{b}

The indexed average values of the same letters and in the same column are not statistically different according to the Student - Newman - Keuls test, at the 5% threshold; UFL:milk fodder unit

obtained at weeks 7 and 8 and from those obtained at week 4. Similarly, the values obtained in weeks 7 and 8 are significantly different (P < 0.05) from those obtained in week 4 (Table 3).

3.5 Nitrogen Value

As far as the crude protein in the grass is concerned, the trend is downwards with age. Thus, from the 4th to the 8th week, the respective values 89; 77; 75; 66, and 62 g MAT/kg DM are observed. Similarly, the digestible nitrogenous matter (MAD) is low and has constantly decreased in the grass over time. Thus, from the 4th to the 8th week, the following values were obtained: 45, 41, 44, 38, and 36 g MAD/kg DM (Table 2). The difference in the MAD content of the regrowth observed at the 4th and 6th week of regrowth is not significantly different (P > 0.05). The same applies to the difference in the 7th and 8th weeks. On the other hand, the values observed are significantly different (P < 0.05) from those obtained at the 5th and 7th, and

8th weeks. The MAD value at week 5 is significantly different ($P < 0.05$) from those at weeks 7 and 8 (Table 4).

Table 4. Comparison of the obtained MAD values

Age of regrowth (weeks)	MAD (Mean ± standard deviation)
4th week	45±10.35[a]
6th week	44±9.53[a]
5th week	41±8.80[b]
7th week	38±7.70[c]
8th week	36±7.36[c]

The average indexed values of the same letters and in the same column are not statistically different according to the Student - Newman - Keuls test, at the 5% threshold; MAD: Digestible Nitrogenous Matter

4. DISCUSSION

Several species of forage plants with pastoral characteristics have been identified. Among them, the fodder Poaceae. They are the most numerous and are represented by *Hyparrhenia smithiana* (Hook.f.) Stapf and *Hyperthelia dissolute* (Nees) Clayton. The Poacea have a very high possibility of tillering and regrowth after grazing. They are therefore resistant to the vagaries of the weather and are rarely affected by cryptogamic diseases. This may explain their high proportion (93.95%) [8, 9].

At the bromatological level, the ageing of these species has been accompanied by an increase in dry matter of 11.20%. The increase in the dry matter content of fodder is partly responsible for the rapid deterioration of the quality of this fodder, since it is too quickly reduced to straw. On the other hand, little change in calcium and phosphorus content was observed. In another study, Gupta et al. [10] reported the same behaviour of calcium and phosphorus during successive cuts of *Trifolium alexandrinum*. Phosphorus behaviour could be related to soil composition but also to the diversity of plants harvested in this study. For this type of pasture particularly low in calcium and phosphorus, an exogenous supply of these elements in the form of stone or lick powder is necessary if animal production using this fodder is not to be compromised.

As far as raw cellulose is concerned, it is immediately high, even in young grass, contrary to what is observed in temperate fodder. Moreover, during the period of study of the grass, the crude fibre content grew steadily but relatively low. In 5 weeks, the total nitrogen content of the forage decreased by almost 21% and the digestible nitrogen content by 9%, reducing the grass to straw value. This behaviour of tropical forages, probably related to climate, is the main penalty affecting our pastures. The too rapid decrease of nitrogen in these forages means that this essential nutrient very quickly becomes a limiting factor in animal production. It is without a doubt responsible for the loss of weight of livestock observed towards the end of the wintering period when the grass is still green and abundant.

As the nitrogen in the grass decreases, the energy value peaks at 6 weeks and decreases slightly to a correct value in the following weeks. According to Boudet's [11] classification, the studied savannah is of excellent quality from an energy point of view at 5 - 6 weeks of regrowth age and average quality at the 4th, 3rd, 7th, and 8th weeks. It is obvious that the forage studied is characterized by a good energy value [11]. This energy value is maintained throughout the study. Due to its nitrogen value, the fodder can be described as being of average quality from the 5th to the 7th week. Beyond 8 weeks, it is a poor quality forage which, according to Boudet [11], cannot meet the maintenance needs of the UBT and whose nitrogen content acts as a limiting factor.

The various nutrients studied (MS, MO and MAT) are less well digested by the 4th week, which is contrary to what is said in the literature where young grass, which is more palatable, is consumed in greater quantities and/or is better digested than older grass. Anti-nutritional substances, linked to the water contained in greater quantities in young grass, may play a role in inhibiting the activity of the rumen bacterial flora [12].

5. CONCLUSION

Several species of forage plants have been identified. Among them, the fodder Poaceae *Hyparrhenia smithiana* and *Hyperthelia dissoluta* are the most numerous. The studied savannah formation has low levels of calcium and phosphorus. It therefore requires continuous mineral supplementation in the form of lick stones. The overall energy value is quite good. As for nitrogen, it is generally deficient in it. The decrease of nitrogen in these forages means that this essential nutrient very quickly becomes a limiting factor in animal production. Its productivity can be significantly improved by a judicious and consequent mineral (powder or licking stone) and nitrogen supplementation. These data show that this pasture must be used between the 5th and 7th week of regrowth age in order to make the most of it.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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