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Productive performance of growing male cattle, supplemented with minerals during the dry season

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Abstract

Objective: To evaluate the weight gain of developing male cattle, supplemented with minerals during the dry season, in a rotational system with *Bothriochloa pertusa* (L.) A. Camus.

Materials and Methods: The study was conducted in grazing areas located at the Motilonia Research Center, Cesar Valley, Colombia. Animals of the commercial breed Brahman were used. The forage availability, live weight, mean daily gain and bromatological composition, were determined. Two treatments were evaluated: T1) with mineral supplement and T2) without mineral supplementation. Each treatment had 10 crossbred animals in two hectares. The design was complete randomized and the information was evaluated through a mixed model, with repeated measures in time through *Proc Mixed* of SAS®.

Results: The group with mineral supplement had increase in live weight of 16,3 % with regards to the one that did not receive it. The values were 78,9 *vs* 66,1 kg, and the mean daily weight gain was significant ($p < 0,001$) (0,438 *vs* 0,367 kg animal^{-1} day^{-1}, respectively). The daily average intake of mineral salt showed significant variations ($p < 0,001$) among the months (between 29,0 and 48,8 g animal^{-1} day^{-1}). The nutritional balances proved that the treatment without minerals showed deficit of Ca, P, Na, Cu and Zn.

Conclusions: With the utilization of a rotational system of *B. pertusa* it is achieved that the growing male cattle gain weight during the dry season, if their dry matter requirements are covered. In addition, if salts that satisfy the deficit of missing minerals (Ca, P, Na, Cu and Zn) are incorporated in the diet, a higher response is obtained.

Keywords: *Bothriochloa pertusa*, season, supplementation, minerals

Introduction

During recent years, in Colombia climate change has been stressed, with extreme variations of temperature, occurrence of increasingly frequent strong rains and prolonged drought periods. These meteorological actions, associated to a large extent to the El niño and La niña phenomena, have affected the performance of ecosystems, among them the ones linked with animal husbandry (Arteaga and Burbano, 2018).

In a diagnosis conducted in the animal husbandry farms of the Cesar Valley during rearing of growing male cattle, fed only with *Bothriochloa pertusa* (L.) A. Camus, the incidence of these meteorological affectations was corroborated, especially because of the limitations in the dry matter (DM) availability shown by the pasture during the dry season (DS). In addition, the evaluations proved that, under these circumstances, the animals also showed nutritional deficits of macrominerals and microminerals (Roncallo-Fandiño *et al.,* 2020).

When under grazing conditions, the concentrations of minerals in pastures do not satisfy the requirements, restrictions occur in the metabolic processes, which reduce the productive performance of cattle (Mijares-López *et al.,* 2012).

According to the criteria develop by Cseh (2015), one of the most serious problems in cattle management is the lack of minerals, because before manifestations of acute deficiencies emerge, the productive yield of the animals is permanently affected. Zanetti *et al.* (2000) indicate that the correction of these limitations through mineral supplementation allows to increase weight gains between 10 and 15 %.

The objective of this research was to evaluate the weight gains of growing male cattle, supplemented with minerals during the dry season in a rotational system with *B. pertusa*.

Materials and Methods

Location and climate. The studies were conducted at the Motilonia Research Center, Codazzi (Cesar

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Valley, Colombia), located at the coordinates 10° 1′ 58,512″ N and 73° 13′ 29,946″ W.

This region corresponds to a plant formation of tropical dry forest and is located in an agroecological zone, with lands of alluvial and colluvial-alluvial plains (Holdridge *et al.,* 1971).

The evaluations were conducted from October first, 2014, to March 30, 2015. The performance of rainfall and temperatures was taken from the meteorological station located in Motilonia (table 1).

Soil characteristics. The soils of the areas were evaluated according to the techniques described in the procedure handbook for soil, water and plant tissue analysis (IGAC, 2009). The samples were taken at the beginning of the research, between 0 and 20 cm of depth. As indicators pH, OM, macroelements (Ca, Mg, K, Na, P and S), microelements (Cu, Fe, Mn Zn and B), effective cation exchange capacity and electrical conductivity, were determined (table 2).

The soils of the experimental areas showed limey clayey-sandy texture, with slightly acid pH. The OM, Mn, S and Zn contents were low, with moderate values for Mg, K, Fe, B, and high for P, Cu and Ca. The Na concentrations were considered normal, which allowed to classify the soils as non-saline (McDowell, 1985).

Treatment and experimental design. Two treatments were evaluated: T1) grazing of *B. pertusa* with mineral supplement and T2) grazing of *B. pertusa* without mineral supplementation. For each treatment 10 growing male cattle were selected, arranged in a complete randomized design, which came from double-purpose systems, with similar breed characteristics.

Animals and management. The males were commercial Brahman, with ages between 10 and 12 months and average live weight (LW) of 132,4 ± 8,2 kg, for an initial stocking rate of 1,47 LAU ha^{-1}. They were clinically healthy upon physical exam, and they had the

Table 1. Monthly average of rainfall and temperature in the Motilonia Research Center.

Variable	2014			2015		
	October	November	December	January	February	March
Rainfall, mm	335,6	316,7	141,7	62,8	40,8	6,5
Temperature, ºC	28,1	28,4	28,4	29,6	30,2	31,1

Table 2. Soil characterization in the experimental areas.

Indicator	Grazing system of *B. pertusa*	
	Without minerals	With minerals
	Limey clayey-sandy	
pH	6,7	6,7
OM, %	1,6	1,4
Available P, mg kg^{-1}	74,8	73,9
Available S, mg kg^{-1}	1,4	2,5
Exchangeable Ca, Cmol (+) kg^{-1}	6,9	6,0
Exchangeable Mg, Cmol (+) kg^{-1}	2,6	2,2
Exchangeable K, Cmol (+) kg^{-1}	0,3	0,2
Exchangeable Na, Cmol (+) kg^{-1}	0,3	0,3
ECEC, Cmol (+) kg^{-1}	10,1	8,7
EC, dS/m	0,3	0,2
Available Fe, mg kg^{-1}	99,0	80,0
Available Cu, mg kg^{-1}	5,4	4,2
Available Mn, mg kg^{-1}	2,7	1,8
Available Zn, mg kg^{-1}	1,0	1,0
Available B, mg kg^{-1}	0,3	0,3

vaccination program established in the region updated and control of endoparasites and ectoparasites.

Experimental procedure. Each treatment had two hectares, subdivided into eight paddocks of 2 500 m^2. The rotation cycle was of four days of occupation and 28 of resting, by the method of rotational grazing in line. The live weight (LW) of the animals was transformed into large animal units per hectare (LAU ha^{-1}), considering 450 kg as reference unit. In proportion with the weight increase, the LAU ha^{-1} evolved in ascending order, and ratified the favorable actions of minerals (table 3).

All the paddocks had 300-L drinking troughs with self-feeding devices. The treatments with mineral supplementation had plastic salt feeders. In each paddock, aluminum structures, covered with shade nets, 3 m high and with 4 x 4 m bases, were installed. Since December, at the entrance of each grazing block a roofed wooden feeding trough (5 m long, 1,5 m wide and 0,5 m high) was placed to offer hay at will. Neither irrigation nor fertilization was used.

The floristic composition of the grazing areas was estimated by the method of steps, described by EEPFIH (1980). This technique consisted in walking by the diagonals in each paddock. Every three steps, the observer classified the pasture species that coincided with the tip of his/her shoe. This measurement was performed at the beginning and the end of the experimental period in 100 % of the paddocks. At the beginning, the pasturelands showed 95 % of the grass *B. pertusa*, 2 % of the species *Megathyrsus maximus* (Jacqs.) B.K. Simon & S.W.L. Jacobs and *Dichanthium aristatum* (Poir.) C.E. Hubb. and 3 % of depopulation. At the end, 90 % of purity, 1 % of species *M. maximus* and *D. aristatum* and 9 % of depopulation, were recorded.

The mineralized salt came from the commercial house Solla-Itagüi, Colombia, and the concentrations of its components were verified in the laboratory of ICA, in Colombia (1989). The certified ingredients were: Ca (9 %), NaCl (55 %), P (4 %), Fe (0,04 %), Mg (0,5 %), S (0,6 %), Zn (0,7 %), Cu (0,3 %), I (0,015 %), Co (0,005 %), Se (0,0075 %) and moisture (5 %). When the animals entered the paddocks, 2 kg of salt were supplied to them in the salt feeders. Upon departure from the paddocks on the fourth day, what they did not consume was weighed to determine the group intake by difference.

When considering the antecedents of the climate performance of the region, and foreseeing that since January the DM availability in pasturelands is not sufficient to satisfy the DM requirements, since December the adaptation of the animals to the consumption of commercial *B. pertusa* hay was started through an *ad libitum* offer as supplement. The supply began at a rate of 3 % LW, according to the weight reached by the animals in the previous month, and 24 h later the non-used hay was weighed to determine the intake by difference. In the first week, this measurement was done on alternate days, in order to find the average and establish an offer of 15 % over the estimation. The fulfillment of this norm was verified every week. At the end of each month, the intake average was calculated. To match the units of the intakes with those used in forages, the hay values were transformed into DM kilogram (100 kg LW^{-1} animal^{-1} day^{-1}).

Forage availability. To estimate the DM availability, the methodology described by Martínez *et al.* (1990) was used. The evaluations were made the day before the entrance of the animals in the paddocks, and the monthly values corresponded to the average of the sampling performed during each month.

Bromatological composition. During the monthly determination of availability, representative samples of the pasture (300 g) were taken to estimate its quality, manually simulating the selection made by the grazing animal. The DM content was determined through dehydration to constant weight, in a forced-air stove at 60 ºC in the Motilonia laboratory. The samples corresponding to the same month were homogenized and a representative portion was sent to the CORPOICA laboratory, in Bogota, to determine the bromatological composition, according to the procedures of the Colombian Agricultural Institute (ICA, 1989): CP, OM, P, Ca, Mg, Na, K, S, Fe, Cu, Mn and Zn.

Table 3. Performance of the stocking rate during the period.

Treatment	LAU ha^{-1}		
	Initial	Final	Average
With minerals	1,5	2,3	1,9
Without minerals	1,5	2,2	1,8

Determination of the live weight (LW). The animals were individually weighed, with monthly frequency and previous fasting of 12 h. A portable mechanical scale trademark Prometálico®, model CUI 1500-E, with capacity of 1 500 ± 0,01 kg, was used. The mean daily gain (MDG) was quantified, expressed in kg animal^{-1} day^{-1}, from the monthly differences of the initial and final LWs, divided by the days that passed between one weighing and the other.

Feeding balance. The nutritional requirements were retrospectively determined, from LW and MDG in each month. As the work was done with animals fed only with pastures, which were permanently in the grazing areas, the DM requirements were considered as equivalent to the ingestion capacities (IC), determined by the CALRAC® program, version 1.0 (ICA, 1996) for beef cattle, just like the requirements for metabolizable energy (ME), crude protein (CP), Ca and P. the other macro- and microminerals were estimated according to the indications established by the National Research Council (NRC, 2000). The ME was retrospectively determined through the CALRAC program. Before making the calculations of the feeding balance, it was determined whether the animals had possibilities to cover their DM requirements. For such purpose, the values of DM availability were transformed into their equivalents in kg DM LW^{-1} animal^{-1} day^{-1}.

Determination of the mineral deficit. To define the reached satisfaction degree, the following criteria and procedures were applied:

a. Each month, from LW and MDGs, the requirements indicated as optimum in the tables of the NRC (2000) were determined.
b. The mineral quantities contributed by the pasture were determined according to the ingested DM and its bromatological composition.
c. When the treatment included mineralized salt, to the pasture contributions the additional quantities of each element were added, according to the supplement intake.
d. The satisfaction or not of the requirements was defined by subtracting the contributed quantities with regards to the required ones.

Determination of the effectiveness of inclusion of minerals. The effectiveness of minerals was determined through the criterion proposed by Rodríguez and Banchero (2007). These authors consider that the most expedite way to determine whether there is subclinical deficit of minerals is through the quantification of productive increases, which are obtained when the animals have, permanently and at will, integral salts that contain the macro- and microelements that participate in the physiological functions of cattle.

Statistical analysis. The effects on productive performance of the utilization or not of mineral supplementation in the animals, were evaluated through a complete randomized design. For the data analysis a mixed model was used, with repeated measures in time, according to the Proc Mixed procedure of SAS® (2013). The variance-covariance structures were tested (compound symmetry, variance components, order 1 autoregressive and non-structured Toeplitz) to decrease the variation sources in the error. To select the model with the variance-covariance matrix of best fit to the data, the information criteria Akaike, corrected Akaike and Bayesian information, were used, for which the lowest value was considered. In this study, the best fit was found in the Toeplitz. The means were compared through Tukey and Kramer mean range test, for $p < 0,05$. In the model the treatments with the addition of minerals and without it, the sampling months, and the possible treatments by months interaction, were considered as effects. As random effect the animals nested in the months were taken into consideration.

Results and Discussion

There was decrease in the availability of DM ha^{-1} rotation^{-1}, from October to December, with important reduction from January to December, which corresponded to the months in which the rainfall was low (table 4). The fact that no significant differences were found in the months indicates that, in both treatments, the animals were under equal conditions.

The results showed the seasonal dependence of *B. pertusa* and confirmed the report by Cajas-Girón *et al.* (2012), who consider that this is the main limiting factor shown by this species to guarantee stable animal productions throughout the year. Taking into consideration these criteria and the results obtained by Roncallo-Fandiño *et al.* (2020), before the forage availability became critical, hay was incorporated since December, as supplement in the feeding management. In both treatments, as the pasture offer decreased, the hay intake increased (table 5).

The incorporation of hay proved the validity of this procedure to guarantee that the growing male cattle could satisfy their DM requirements in the face of the deficit of *B. pertusa* availability during the dry season.

Table 4. Performance of the availability of DM ha^{-1} rotation^{-1}.

Moment	With minerals	Without minerals	SE ±	P - value
Beginning	1 299,3	1 288, 9	27,23	0,04
October	1 242,4	1 164,7	38,10	0,19
November	1 190,6	1 046,2	33,02	0,62
December	1 160,2	1 010,3	13,61	0,34
January	860,7	850,4	42,35	0,72
February	740,9	730,2	39,02	0,65
March	730,5	725,2	37,92	0,66

Table 5. Hay intake and its equivalence for every 100 kg of live weight (LW).

Indicator	December	January	February	March	December	January	February	March
	With minerals				Without minerals			
kg DM animal^{-1} day^{-1}	1,43	2,02	2,69	3,75	1,28	1,93	2,29	3,28
kg DM 100 kg LW^{-1} animal^{-1} day^{-1}	0,84	1,12	1,36	1,77	0,79	1,13	1,38	1,65

The average bromatological indicators showed that the hay presented lower percentages with regards to the forage, and the standard deviations showed that the mean values had little oscillation (table 6).

The nutritional contributions of the offered forages in both treatments were very similar, aspect that was very important because it guaranteed that the studies were conducted under equal conditions.

The metabolizable energy was higher than the one found for this pasture during the dry season by Roncallo-Fandiño *et al*. (2020), but it was close to that reported as reference value by Mendoza *et al.* (2018).

The CP, Ca and P percentages were within those found by Cajas-Girón *et al*. (2012). Nevertheless, according to the report by Chamorro *et al*. (2005), with the exception of Na, the Ca, P, Mg, K and S percentages were lower; while Fe, Mn, Cu and Zn showed higher concentrations.

According to the ranges suggested by McDowell (2017) for tropical pastures, *B. pertusa* showed high concentrations of Ca, K and Mg, and low, of P and

Table 6. Average bromatological composition of the feedstuffs.

Indicator	*B. pertusa*				Hay	
	With minerals		Without minerals			
	Mean	SD	Mean	SD	Mean	SD
ME, Mj kg^{-1}	8,9	0,690	8,8	0,640	6,2	0,700
CP, %	10,8	0,720	10,2	1,100	8,4	0,380
Ca, %	0,3	0,130	0,3	0,120	0,3	0,030
P, %	0,3	0,030	0,2	0,020	0,2	0,020
K, %	1,7	0,470	1,3	0,530	1,3	0,060
Na, %	0,0	0,010	0,0	0,010	0,0	0,010
Mg, %	0,2	0,120	0,2	0,100	0,2	0,020
S, %	0,2	0,120	0,2	0,100	0,2	0,010
Fe, mg kg^{-1}	185,3	67,520	186,7	65,270	204,0	7,550
Cu, mg kg^{-1}	8,5	1,390	10,0	1,750	7,0	2,000
Mn, mg kg^{-1}	44,8	16,180	49,9	24,290	25,3	1,530
Zn, mg kg^{-1}	28,3	18,090	26,6	2,650	23,3	2,520

Na. Regarding microelements, the Fe content was adequate, Mn high, Zn marginal, and Cu deficient.

The lowest concentration in the bromatological composition of hay with regards to the grazing material was ascribed to the quality of the forages that originated them, because they came from non-assisted areas, which had not been grazed since the rainy season until their harvest, at the beginning of the DS. When applying the hay, in the evaluation criteria of the pastures it was found that the percentages of P, Ca and Na were low; while those of K and Mg were high. The Fe content was adequate, the Mn, lower than optimum, Cu, deficient, and Zn, marginal. In general, the minerals showed lower concentrations, with the exception of Na, S and Mn.

When forages constitute the main feeding resource, mineral nutrition can become critical, due to the dependence that is established between the needs of the animals and the composition of the consumed pastures (Patiño *et al*., 2011).

Figure 1 shows the increase of live weight of the treatments. At the beginning, the groups did not show significant differences in their values, and maintained this condition until January. However, since this month there were significant increases ($p < 0{,}001$), in favor of the group with mineral supplement.

Mijares-López *et al*. (2012) stated that during the periods of the year with scarce rainfall, in the systems that depend only on pastures, the low availability of forages limits the possibilities of obtaining higher weight gains. Nevertheless, the results showed that, through the incorporation of hay, this behavior can be reversed.

The hay supply proved to be a fundamental procedure to guarantee that the growing male cattle maintained their weight gains and increased their productive yields. In addition, it is important to take into consideration that, when the animals satisfy part of their DM requirements with another feedstuff, they do not overgraze, which contributes to preserving pasturelands and maintaining the resilience of the system (FCV-UNNE, 2016).

The increase in mean weight gain of the treatment supplemented with minerals (figure 2) ratified that the correction of the deficit of these

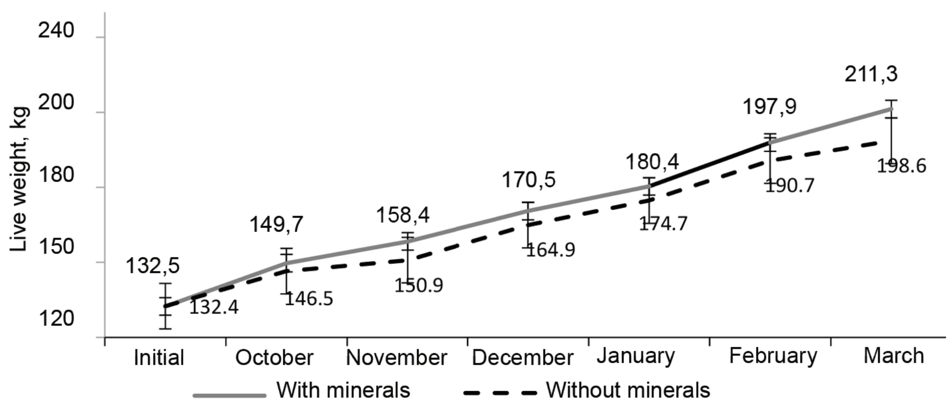

Figure 1. Performance of live weight with mineral supplementation and without it
$p < 0{,}001$

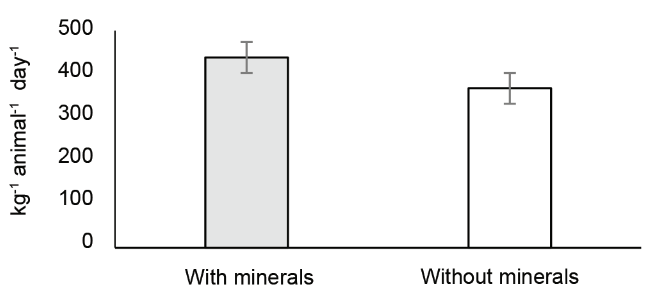

Figure 2. Average mean daily weight gain with mineral supplement and without it
$p < 0{,}001$

elements is determinant to achieve better utilization of the nutritional potentials present in pastures. The results indicated that the supplementation with minerals promotes sustained increases of weight in time, because by the end of the research there was increase in the live weight of 16,3 % in the supplemented treatment, compared with the one that did not receive supplement (78,9 *vs* 66,1 kg).

The daily average intake of mineral salt showed significant variations ($p < 0,001$) among the months (figure 3), with values between 29,0 y 48,78 g animal^{-1} day^{-1}. The highest value was achieved in January, and the lowest in November; while December and March differed from February, but not from October. The intake average in this period was 38,4 g animal^{-1} day^{-1}.

These intakes are within the range (50 g) suggested by González (2018) as average value for growing cattle, although this author indicates that the quantities vary according to the production level and diet quality, and that they are not necessarily in correspondence with higher or lower weight gains.

During the study, the total forage offer guaranteed, in both treatments, that the animals did not show restrictions to satisfy their DM requirements, because through the inclusion of hay it was feasible to maintain the forage offer levels, equal to or higher, than the ones that are considered adequate (table 7).

The nutritional balance indicated that the requirements of DM, CP, K, Mg, S, Fe and Mn could be covered in both treatments, and in the supplemented one all the minerals were covered. However, when no supplementation was used the animals showed deficit of five elements (Ca, P, Na, Cu and Zn) (table 8).

In October, December and March there were limitations (g animal^{-1} day^{-1}) of Ca, with values that varied between 0,9 and 1,7. In all the months there was deficit of P (from 0,8 to 4,2) and of Na (from 2,7 to 3,6). This situation also appeared in Cu, except in November, with values (mg animal^{-1} day^{-1}) from 9 to 14. In the case of Zn, only the requirements corresponding to December were covered, and the limitation ranges varied from 5 to 33 mg animal^{-1} day^{-1}.

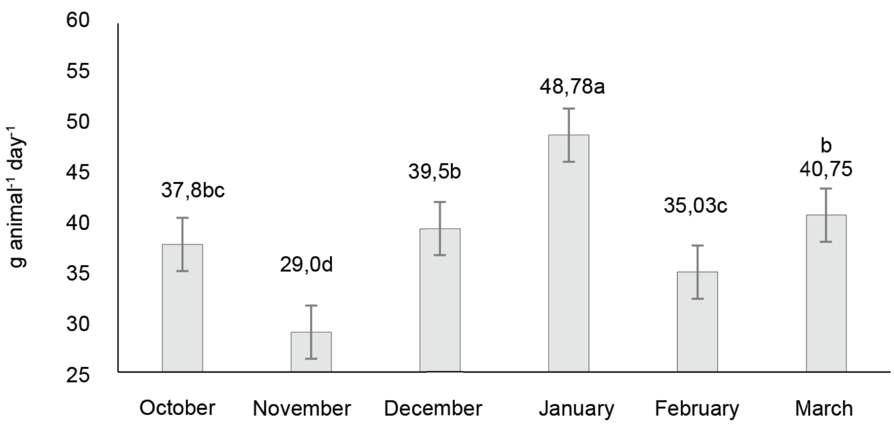

Figure 3. Daily average intake of mineral salt
a, b, c, d. Different letters in the row indicate significant differences

Table 7. Performance of the forage offer levels (kg DM 100 kg LW^{-1} animal^{-1} day^{-1}).

Months	With minerals				Without minerals			
	IC	Forage offer	Hay intake	Total offer	Ingestion capacity	Forage offer	Hay intake	Total offer
October	3,0	5,4	0,0	5,4	3,0	5,1	0,0	5,1
November	2,9	4,5	0,0	4,5	3,0	4,6	0,0	4,6
December	2,9	4,2	0,8	5,0	2,9	4,2	0,8	5,0
January	2,8	3,1	1,1	4,2	2,9	3,1	1,1	4,2
February	2,7	2,9	1,4	4,3	2,8	3,0	1,4	4,4
March	2,7	2,2	1,8	4,0	2,7	2,4	1,7	4,1

IC: ingestion capacity

Table 8. Nutritional balance of growing male cattle, not supplemented with minerals.

Months	Indicator	Ca, g	P, g	Na, g	Cu, mg	Zn, mg
October	Requirement	17,2	11,9	3,5	44	133
	B. pertusa	15,5	11,1	0,4	35	128
	Difference	-1,7	-0,8	-3,1	-9	-5
November	Requirement	17,6	12,2	3,6	45	135
	B. pertusa	17,6	11,2	0,9	50	117
	Difference	0,0	**-0,9**	**-2,7**	5	**-18**
December	Requirement	18,3	12,7	3,8	47	141
	B. pertusa	17,4	11,3	0,5	38	141
	Difference	**-0,9**	**-1,4**	**-3,3**	**-9**	0
January	Requirement	19,3	13,4	4	50	149
	B. pertusa	18,9	6,5	0,2	30	82
	Hay	6,14	3,8	0,2	10	46
	Difference	5,77	**-3,1**	**-3,6**	**-10**	**-21**
February	Requirement	20,5	14,2	4,2	53	158
	B. pertusa	15,8	6,3	0,8	29	70
	Hay	7,9	4,5	0,5	24	55
	Difference	3,2	**-3,4**	**-2,9**	0	**-33**
March	Requirement	21,1	14,6	4,3	54	162
	B. pertusa	10,9	5,1	0,5	19	66
	Hay	8,5	5,3	0,3	23	85
	Difference	-1,6	-4,2	-3,5	-12	-11

These lacks had repercussions on the productive responses of growing male cattle because they limited the performance of physiological and metabolic functions, where the found deficit elements intervene.

Pittaluga (2009) considers as determinant satisfying the demands for Ca and P of cattle in the different growth stages, due to the role they play in bone formation. Likewise, he insists on the fundamental actions of Na in the regulation of the acid-base balance of the blood plasma, in the transport of nutrients at cell level and in the transmission of nervous impulses.

Villanueva (2018) considers Cu as one of the most important microelements, due to the multiple functions in which it participates. It is essential in the formation of hemoglobin, in elastin, necessary protein for the cardiovascular apparatus and the skin. Besides, it intervenes in the synthesis of myelin that covers the central nervous system, in the production of collagen, important protein in the development of bones, cartilages and tendons, and also participates in the melanin levels, essential compound for hair pigmentation.

Zn is considered essential for a group of enzymes linked to the metabolism of carbohydrates, proteins and nucleic acids and for the functioning of the immune system (Bauer *et al*., 2009).

Conclusions

With the utilization of a grazing system of *B. pertusa* it is achieved that growing male cattle gain weight during the dry season, if their dry matter requirements are covered. In addition, if salts that cover the requirements of the deficit minerals (Ca, P, Na, Cu and Zn) are covered, higher response is obtained.

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Authors' contribution

- Belisario Antonio Roncallo-Fandiños. Conducted the trials and data collection. In addition, prepared the work for its publication.
- Félix Ojeda-García. Conceptualized the idea of the research and supervised the research activity. Participated in the writing and revised the manuscript.
- Mildrey Soca-Pérez. Carried out the statistical analysis. Participated in the writing and revised the manuscript.

Conflicts of interests

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

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