Journal of Animal &Plant Sciences, 2013. Vol.18, Issue 2: 2711-2722
Publication date 30/6/2013, http://www.m.elewa.org/JAPS; ISSN 2071-7024

Performance of young bulls supplemented with different relation of protein and carbohydrate from suckling phase until slaughter in tropical pasture

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Keywords associative effects, beef cattle, calf, grazing, multiple supplement, production

1 SUMMARY

The effects of supplementation with different relations of carbohydrate and protein on performance of young bull from 4 until 18 months were assessed. Fifty-five beef calves with an average initial body weight of 138.3±3.4 kg and age between 90 and 150 days were used. Animals were submitted to a 430-days experimental period. The experimental treatments consisted of a Control= mineral mixture only; HPHC= high protein and high carbohydrate supplement; HPLC= high protein and low carbohydrate supplement; LPHC= low protein and high carbohydrate supplement; LPLC= low protein and low carbohydrate supplement. The amount of supplement was adjusted every 28 days. The non-supplemented animals presented lower (P<0.05) average daily gain (ADG) than supplemented animals. Non-supplemented animals presented lower (P<0.05) DM intake than supplemented animals in the dry season. However, in the rainy period, differences were not observed (P>0.05) in DM intake. Nutritionals plans with low supply of carbohydrate (HPLC and LPLC) presented greater supplement use efficiency. It can be concluded that supplementation increase performance of young bulls belong the productive cycle. However, nutritional plans that supply low amount of carbohydrate (until 15% of TDN requirement) have greater efficiency of supplement use.

2 INTRODUCTION

In Brazil, as in most tropical regions, beef cattle production is realized mainly in pasture conditions. However, tropical pasture does not usually present appropriate nutritional balance to maximize weight gain. Thus, multiple supplementation increases the performance in dry season (Goes *et al.,* 2010, Porto *et al.,* 2011, Valente *et al.,* 2011) as well as in rainy season (Acedo *et al.,*, 2011, Barros *et al.,* 2011a, Barros *et al.,* 2011b). Most works on grazing cattle production conditions involves a specific year period and/or a part of production cycle; thus, it is not possible to create a holistic view on production system of supplemented grazing cattle because usually studies do not evaluate the whole productive cycle, considering differences and interaction through the year. Therefore, it is not possible consider the residual effects of supplementation and the results may be conflicting with the ones found in commercial production system. Strategic supplementation among seasons, supplying limiting nutrients and increasing efficiency of pasture use, is an important way to provide continuous growth for grazing cattle. The multiple supplementations throughout the year improve individual weight gain and production per area (Fernandes *et al.,* 2010). The performance of supplemented grazing cattle is a function of many factors such as pasture quality, supplementary nutrients, and relationship between the substrates, especially between protein and energy. The supplementation of protein and carbohydrate jointly or separately determines the interaction effects on intake and digestibility (Souza *et al.,* 2011). However, the intensity of these effects is determined by composition of the basal diet (pasture). Thus, the aim of this study was to evaluate the effects of supplementation with different relationship between carbohydrate and protein on performance of young bulls from 4 until 18 months of age.

3 MATERIAL AND METHODS

3.1 Animals, experiment design and diets: The experimental protocol and procedures were approved by the Universidade Federal de Viçosa Animal Care and Use Committee. This experiment was carried out at the beef cattle facility of the Universidade Federal de Viçosa, in Viçosa, MG, Brazil (20°45' S 42°52' W). The experimental area is located in a hilly area at an altitude of 670 m with an average slope of 34%. This study was carried out between March of 2010 and April of 2011. The weather data is presented in Figure. 1.

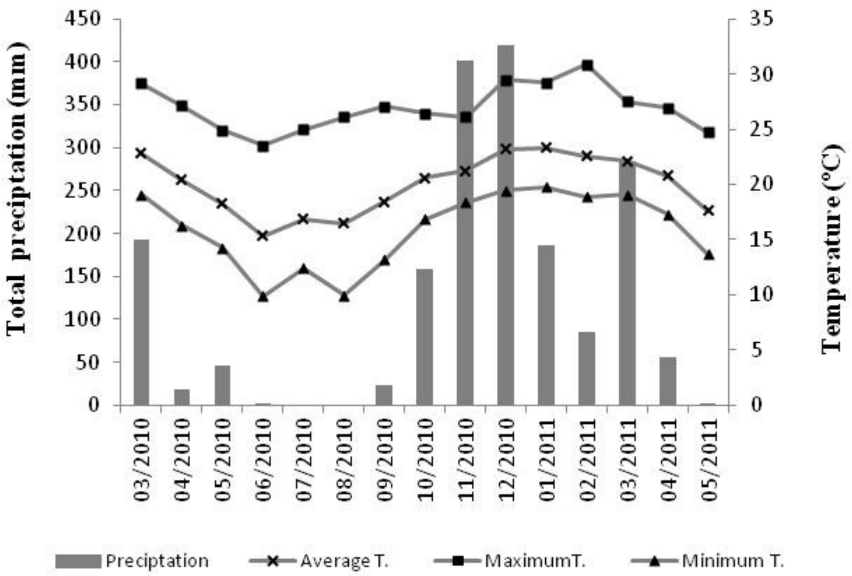

Figure 1: Precipitation, average temperature (Average T.), maximum temperature (Maximum T.) and minimum temperature (Minimum T.) belong the experimental period.

Animals were submitted to a period of 14 days for adaptation and a 430-days experimental period for evaluation of performance, divided into 4 phases: Phase 1= suckling phase in rainy-dry transition season (112days); Phase 2= post-weaning in dry season (84 days); Phase 3= post-weaning in the dry-rainy transition season (84 days); Phase 4= finishing phase in the rainy season (150 days). Fifty-five beef calves with average initial body weight of 138.3 $\pm$ 3.4 kg and between 90 and 150 days of age and their dams (30 Nellore; 10 ½ Nellore ½ Holstein; 15 ¾ Nellore ¼ Holstein), were used. Only Nellore sires were used in this study. Two animals from each treatment in the end of phase 1 and one animal from each treatment in the end of phases 2 and 3 were randomly taken away from their groups to realize other measures. The animals were housed in a 10-ha paddocks of signal grass (*Brachiaria decumbens*) in phase 1 and in 2.5-ha in others phases, provided with feeders covered with asbestos tiles and privative feeders for calves (0.5 m per animal) and drinkers. The nutritional plans, which were randomly assigned, to animals were: control = animals receiving mineral mixture only; HPHC = high protein and high carbohydrate supplement; HPLC = high protein and low carbohydrate supplement; LPHC = low protein and high carbohydrate supplement; LPLC = low protein and low carbohydrate supplement (Table 1).

Table 1: Composition of supplement

	Nutritional plan[1]				
	Control	**HPHC**	**HPLC**	**LPHC**	**LPLC**
Corn	-	55.0	0.0	83.5	53.0
Corn gluten	-	3.0	20.0	0.0	14.0
Soybean meal	-	37.0	70.0	12.0	24.0
Urea/ A.S.[2]	-	1.0	2.0	0.5	1.0
MM[3]	100	4.0	8.0	4.0	8.0

[1] HPHC = high protein and high carbohydrate supplement; HPLC = high protein and low carbohydrate supplement; LPHC= low protein and high carbohydrate supplement; LPLC = low protein and low carbohydrate supplement. [2] Urea + ammonia sulfate (9:1). [3] Mineral mixture; composition: calcium: 8.7 %, phosphor: 9.0 %, sulfur 9.0 %, sodium: 18.7 %, zinc 2400.00 mg/kg, copper: 800.00 mg/kg, manganese: 1600.00 mg/kg, iodine: 40.00 mg/kg, cobalt: 8.00 mg/kg, selenium: 8,16 mg/kg.

Approximately 50 and 25% of the protein requirement were supplied in high and low protein supplement, respectively, and about 30 and 15% of the total digestible nutrients (TDN) requirement was supplied in high and low carbohydrate supplement, respectively. Half of the stipulated requirements were supplied by supplement in phase 1 due to the milk intake in this phase. The amount of supplement was adjusted every 28 days by using the estimated protein and energy requirement by BR-CORTE (Valadares *et al.,* 2006), considering the weight gain in the adaptation period to first adjust of the supplementation and the previous 28 days' weight gain to adjust in the other periods. The supplement composition was formulated for all supplements have similar protein profile with same proportion of protein from each ingredient (Table 2).

Table 2: Chemical composition of supplement and pasture

	Supplement[1]				Pasture[2]			
	Control	**HPHC**	**HPLC**	**LPHC**	**Phase 1**	**Phase 2**	**Phase 3**	**Phase 4**
Dry matter	87.1	89.5	85.8	87.0	29.6	42.5	28.0	21.3
Organic matter	89.3	87.4	88.4	85.8	91.4	92.4	92.4	91.5
Crude protein	29.2	55.3	15.4	29.5	8.8	5.5	12.1	10.7
apNDF[3]	8.7	10.2	7.4	9.2	65.3	65.0	61.5	61.6
Ether Extract	2.6	1.5	3.0	2.4	1.2	1.2	1.5	1.2
CNF[4]	46.2	23.3	57.2	43.6	16.1	20.7	17.3	17.9
Lignin[5]	0.4	0.8	0.2	0.3	4.9	4.4	3.6	2.7

[1] HPHC = high protein and high carbohydrate supplement; HPLC = high protein and low carbohydrate supplement; LPHC= low protein and high carbohydrate supplement; LPLC = low protein and low carbohydrate supplement.
[2] Obtained by handle plucked sampling; Phase 1= suckling phase in rainy-dry transition season (112days); Phase 2= post-weaning in dry season (84 days); Phase 3= post-weaning in the dry-rainy transition season (84 days); Phase 4= finishing phase in the rainy season (150 days).
[3] Neutral detergent fiber corrected for ash and protein. , [4] Non-fibrous carbohydrates., [5] Corrected for ash.

The calves were supplemented once a day at 11 a.m. In order to minimize effects of possible differences of pasture between the paddocks on experimental treatments, the animals were rotated among the five pasture paddocks every seven days, allowing each group stay in each paddocks for the same period of time and intake similar pasture, differing only the supplement intake. The calves were weaned after the end of phase 1, when they were about eight months, 112 days after the beginning of experimental period.

3.2 Experimental procedures and sampling: Forage samples were randomly taken, every 28 days, in order to evaluate the forage mass per hectare. In each plot, six forage samples were randomly selected by using a metal square (0.5 x 0.5 m) and cut at approximately 1 cm above the soil. After that, forage subsamples (200 g) were dried at 60ºC for 72 hours and ground to pass through a 1-mm screen. Every seven days, a manual grazing simulation was performed simultaneously to the observation of grazing behavior of the animals in order to obtain samples to evaluate for chemical composition of the forage consumed by the animals. All samples were dried at 60ºC for 72 hours, ground to pass through 1-mm screen, and proportionally sub-sampled to a composite sample per period. In order to evaluate forage intake and digestibility, a digestion trial (eight days), was performed simultaneously to evaluate the performance of animals in the middle of each production phase. Fecal dry matter excretion was determined by using chromic oxide as an external marker, 10, 12, 14 and 16 g/day to phases 1, 2, 3 and 4, respectively. These portions were packaged in a paper cartridge and directly introduced into the esophagus through a rubber tube. The animals received the marker once daily at 11 a.m., during the first seven days of the digestion trial. To evaluate individual intake of the supplement 10, 12, 14, and 16 g/day of titanium dioxide was mixed with the supplement and offered to animals in phases 1, 2, 3, and 4, respectively. The forage intake was estimated by using indigestible neutral detergent fiber (iNDF) as an internal marker. After five days of adaptation, feces samples were collected at 3 p.m. on the 6th day, at 11 a.m. on the 7th day, and at 7 a.m. on the 8th day of the digestion trial period. The fecal samples were dried at 60 ºC for 72 hours, grounded to pass through 1-mm screen sieve, and proportionally sub-sampled to a composite sample by phase. Milk intake by calves was estimated on days 28, 56 and 84 of the experimental period (phase 1). Cows were separated from their calves at 6 p.m. At 6 a.m. of the next day, cows were milked immediately after an injection of 2 mL of oxytocin (10 IU/mL; Ocitovet®, Brazil) in the mammary vein and the produced milk was weight. The milking was planned to do not occur time longer than 2 hours from the first and the last cow milked. The exact time when each cow was milked was recorded and the milk production was converted into a 24-hours production. The milk produced was corrected to 4% of fat (4% fat-milk) calculated by the following equation (NRC 2001):

4% fat-milk (kg) = 0.4 x (milk production) + [15 x (fat production x milk production/100)

After 16h of fasting, the animals were weighted in the beginning and in the end of each phase.

3.3 Chemical analysis: Samples of forage, feces and supplement ingredients were analyzed for dry matter (DM, index no. 920.39), crude protein (CP, index no. 954.01), organic matter (OM, index no. 942.05) and ether extract (EE, index no. 920.39) as described by AOAC (Association of Official Analytical Chemists, 1990). Lignin content was obtained by cellulose solubilization in sulfuric acid (Van Soest & Robertson 1985). For analysis of neutral detergent fiber (apNDF), samples were treated with thermostable α-amylase without sodium sulfite and corrected for ash residue (Mertens, 2002) and residual nitrogen compounds (Licitra *et al.,* 1996). The iNDF content was evaluated using F57 (Ankon®) bags incubated in rumen by 288 (Valente *et al.,* 2011b). Fecal samples were evaluated for chromium and titanium dioxide content by using atomic absorption (Willians *et al.,* 1962) and colorimetric (Myers *et al.,*, 2004) methods, respectively.

Content of non-fibrous carbohydrate, corrected for ash and protein (NFCap), was calculated by using the following equation (Detmann & Valadares Filho 2010):

NFC = 100 − [(%CP − %CP urea + % of urea) + %apNDF + %EE + %ash]

Mass of forage samples obtained was analyzed for DM, as previously described. Milk was analyzed for protein, fat, lactose, and total solids content, using spectroscopy (Foss MilkoScan FT120, Hillerød, Denmark). The fecal excretion was estimated by ratio of the marker dose (chromic oxide) and its concentration in the feces. The dry matter intake (DMI) was estimated by using the iNDF as an internal marker and calculated by the following equation:

DMI (kg/day) = [((FE x iNDF feces) – iNDF supplement) ÷ iNDF forage] + SI + MI,

Where FE is the fecal excretion (kg/day); iNDF feces is the concentration of iNDF in the feces (kg/kg); iNDF supplement is the iNDF in the supplement (kg); iNDF forage is the concentration of iNDF in forage (kg/kg); SI is the supplement intake and MI is the milk intake.
The estimation of the individual intake of supplement was obtained by using the external marker titanium oxide by using the following equation:

SI = (FE × MCF)/MCS,

Where SI is the dry matter supplement intake (kg/day); FE is the fecal excretion (kg/day); MCF is the marker concentration in the feces (kg/kg); MCS is the marker concentration in the supplement (kg/kg).
3.4 Statistical analysis: This study was carried on using a completely randomized design using a 2 x 2 + 1 factorial arrangement to evaluate the nutritional plans (two protein levels, two carbohydrate levels and one control). Initial body weight of the calves and initial body weight and body condition score of the cow were used as covariate for the data analysis.
The variables will be evaluated according to a complete random design in a time repeated measures design by using mixed models methods according to the model (Kaps & Lamberson, 2004):

$$Y_{ijk} = \mu + P_i + F_j + (P \times F)_{ij} + \varepsilon_{ijk}$$

Where: Yijk is the response variable measured in the experimental unit k submitted to the nutritional plan i in the j phase; µ is the overall constant; Pi is the effect of the i nutritional plan (fixed effect); Fj is the effect if j performance phase (random effect); (PxF)ij is the interaction between the principal effects (fixed effect); eijk is the non-observable random error, presupposed by the normal distribution. The best structures of matrix of (co)variance were defined by using the Akaike's information criteria. Significant difference was considered at P<0.05. The data were analyzed by using the MIX procedure of SAS version 9.1

4 RESULTS

The annual precipitation was about 1500 mm, out of which 90% occurred from October to March (Figure 1). Average forage mass throughout the experimental period was 3.88, 3.89, 3.06, 3.18 ton/ha in phase 1, 2, 3, and 4, respectively. The crude protein (CP) of forage was affected by season, with 8.8, 5.5, 12.1, 10.7% CP in Phase 1, 2, 3, and 4, respectively (Table 2). Moreover, about 30% of CP was associated to fiber, being slowly available to ruminal microorganisms. The average milk intake by calves was 6.2 kg/day. In phases 1, 2 and 3, the non-supplemented animals presented lower (P<0.05) intake of DM and total digestible nutrients (TDN). Although differences in DM intake, in phase 4 (rainy season), were not observed (P>0.05) between supplemented and non-supplemented animals, the supplemented animals presented greater TDN intake.
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In addition, all treatments presented greater (P<0.05) intake of DM and TDN in the rainy season (phase 3 and 4) than in the dry season (phase 1 and 2) (Table 3). The non-supplemented animals presented lower (P<0.05) average daily gain (ADG) than supplemented animals in all phases (Table 4). In phases 1 and 4, differences were not observed (P<0.05) among types of supplement. However, in phase 2, the nutritional plan with high protein and high carbohydrate (HPHC) presented greater (P<0.5) performance. In addition, in phase 3, nutritional plan with high carbohydrate (HPHC and LPHC) presented greater (P<0.05) performance. However, the nutritional plans with low carbohydrate (HPLC and LPLC) presented similar (P>0.05) weight gain to the non-supplemented animals

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Publication date 30/6/2013, http://www.m.elewa.org/JAPS; ISSN 2071-7024

Table 3: Intake of supplement, total dry matter and total digestible nutrients (TDN) and efficiency of supplement use

Nutritional plans	Production phase			
	Phase 1	**Phase 2**	**Phase 3**	**Phase 4**
	Supplement intake (kg)			
Control	-	-	-	-
HPHC	0.734	0.946	0.996	1.758
HPLC	0.344	0.504	0.511	0.771
LPHC	0.671	0.934	0.856	1.768
LPLC	0.353	0.449	0.477	0.793
SE	0.09	0.10	0.12	0.12
	Total dry matter intake (g/kg BW)			
Control	14.68Bb	13.14Bb	21.63Ba	20.66a
HPHC	17.58Ac	19.30Abc	23.10ABa	20.59ab
HPLC	18.28Ab	16.20ABb	24.78Aa	21.91a
LPHC	17.06BAb	17.50Ab	23.69ABa	19.52b
LPLC	15.66ABc	16.70Abc	23.44ABa	18.87ab
SE	1.00	1.10	1.20	1.40
	TDN intake (g/kg BW)			
Control	11.04Ba	7.44Cb	12.43Ba	10.88Ba
HPHC	13.91Aa	11.88Ab	14.99Aa	13.18ABa
HPLC	13.48ABab	9.85ABc	15.77Aa	13.49Ab
LPHC	12.11ABab	10.55ABb	14.19ABa	12.05ABab
LPLC	11,87Bb	9.69Bc	14.26ABa	12.52ABab
SE	0.68	0.76	0.82	0.97
	Efficiency of supplement use (kg/kg)			
Control	-	-	-	-
HPHC	0.280	0.383	0.112	0.102
HPLC	0.430	0.550	0.170	0.167
LPHC	0.322	0.244	0.153	0.117
LPLC	0.575	0.483	0.161	0.247
SE	0.09	0.10	0.10	0.11

Different subscript lowercase letters within a row denote significant difference according to period ($P<0.05$) and different subscript capital letters within a column denote significant difference according to nutritional plans ($P<0.05$).

Table 4: Least square means and standard error (SE) for final body weight and average daily gain (ADG) of young bulls according to the nutrition plan and production phase

Nutritional plans	Production phase			
	Phase 1	Phase 2	Phase 3	Phase 4
	Final Body weight (kg)			
Control	208.1c	220.6Bc	248.5Bb	343.5Ba
HPHC	231.3d	278.3Ac	312.9Ab	438.3Aa
HPLC	224.0d	264.2Ac	302.3Ab	412.7Aa
LPHC	232.9d	264.7Ac	305.1Ab	428.3Aa
LPLC	228.6d	261.0Ac	306.7Ab	429.3Aa
SE	10.46	11.56	12.27	13.11
	ADG (kg/day)			
Control	0.613Ba	0.141Cc	0.346Bb	0.617Ba
HPHC	0.818Aa	0.503Ab	0.458Ab	0.796Aa
HPLC	0.761Aa	0.418ABb	0.433ABb	0.746Aa
LPHC	0.829Aa	0.369Bb	0.477Ab	0.823Aa
LPLC	0.816Aa	0.358Bb	0.423ABb	0.813Aa
SE	0.03	0.03	0.03	0.04

Different subscript lowercase letters within a row denote significant difference according to period ($P<0.05$) and different subscript capital letters within a column denote significant difference according to nutritional plans ($P<0.05$).

Animals presented better ($P<0.05$) performance in phases 1 and 4. The control animals presented the lowest ($P<0.05$) ADG in the dry season (phase 2). However, differences were not found ($P>0.05$) in performance of supplemented animals between dry season (phase 2) and dry-rainy transition phase (phase 3). The supplemented animals presented final body weight 94.8, 69.2, 84.8, and 85.5 kg higher than control animals in HPHC, HPLC, LPHC, and LPLC, respectively. Considering the additional gain regarded to Control animals of the best nutritional plan (HPHC) and ADG of control animals at post-weaning, the non-supplemented animals needed 258 more days to reach the weight of animals of HPHC animals at 18 months of age. Nutritionals plans with low supply of carbohydrate (HPLC and LPLC) had greater supplement use efficiency. Supplement use efficiency was greater (Table 3) for low quality pastures (phase 1 and 2).

5 DISCUSSION

5.1 Standing Forage and Forage Quality: The pasture presented high CP in rainy season, as expected for this season, being higher after the early rains, when the plans starting to grow and they are at the immature stage (Table 2). Nonetheless, in the early growth stage of a plant, a significant part of CP is non-protein nitrogen (NPN) (Valente *et al.,* 2011). Thus, the animal may have deficit of metabolic protein, even with a high intake of CP. In tropical pastures, protein is the major limiting factors to production. Figueiras *et al.,* (2010) proposed the value of 9% CP as value that optimizes the forage use by grazing cattle. However, performance increased as dietary protein increased, even when protein level of forage was higher than 9%. The animal response to supplementary protein occurred in all phases, including rainy season when pasture presents high CP levels. Thus, in phases that pasture present low CP level the improvement of performance occur by supplying of quantity deficit of CP, but when pasture presents high CP level, the performance may be improved by supply of quality deficit, because in tropical plants, a significant amount of protein is associated to fiber as neutral detergent insolvent protein (NDIP) (Table 2) that is slowly available to ruminal microorganisms. Forage mass was not greater in the rainy season. Although the plant had presented accelerated growth, the increase of grazing pressure, due to of growth of animals, prevented the accumulation of forage. However, if there is a minimum quantity of forage mass to supply animal demand, canopy structure, and nutritive value are more important than forage mass to pasture intake. Thus, forage mass may present a secondary importance on animal performance. Casagrande *et al.,* (2011) observed similar forage composition and animal performance when forage mass ranged by approximately 50%.

5.2 Feed intake: At early ages, calves get most energy and nutrients from milk. However, as they grow up, nutritional requirement of calves increases and milk intake reduces. Thus, the milk became insufficient to supply nutritional requirement of calves (Henriques *et al.,* 2011) and a gradual replacement of milk by solid feeds takes place. Milk and pasture were not sufficient to supply substrate demand to reach the genetic potential of calves and they responded to concentrate supplementation, corroborating with Valente *et al.,* (2012). In the dry season (phase 2), the pasture presented low protein content. Thus, it is likely that non-supplemented animals presented low activity of rumen due to protein deficiency, which is in turn, limited by the DM intake at low levels. In this period, the energy extraction from fibrous-carbohydrates is limited, especially, due to deficit of nitrogen compounds for the enzymatic systems of ruminal microorganisms (Sampaio *et al.,* 2009; Detmann *et al.,* 2009). However, nitrogen assimilation in rumen may be increased with joint supplementation of CP and NFC (Detmann *et al.,* 2005, Souza *et al.,* 2010). Therefore, when animals were supplemented with protein, DM intake increased, which were intensified with joint supplementation of protein and carbohydrate (HPHC). The dry-rainy season transition period is characterized by a dramatically change of forage quality, with increase of availability of forage at immature physiological stage, presenting high CP level and high-quality NDF, with scarce contend of lignin. In the rainy season, forage quality is improved with a consequent increase in the passage rate (Estrada *et al.,* 2010), degradability of DM and intake of effectively degradable DM (Ortiz *et al.,* 2010). With the forage maturity, it occurs an increase of protein fraction associated to fiber that is slowly available and of protein fraction associated to fiber, which is unavailable (Costa *et al.,* 2011b). Therefore, the protein available to animals reduces with plant maturity. Nonetheless, in grazing system with stable stocking rate, it is difficult to keep plants in immature stages. Thus, when protein supplement is supplied, the protein available in the ruminal environment is increased and, therefore, rumen kinetic characteristics and intake of digestible DM are improved. Although supplemented animals presented greater performance when pasture presented high CP level (phase 3 and 4), the total DM intake was not improved with supplementation. A partial substitution of pasture intake by supplement occurred. However, the supplementation may have improved available energy and nutrients to animal, even if there were no changes in the consumption, being confirmed by increased of TDN (Table 3). In the rainy season (phase 4), similarly to other studies (Zervoudakis *et al.,* 2008, Costa *et al.,* 2011a), the protein supplementation did not change DM intake. Although protein supplementation increases NDF degradation rate (Costa *et al.,* 2011b), no changes occur in DM intake. Therefore, rumen repletion does not determine the consumption in this season; the physiologic or metabolic mechanisms were the likely controllers of consumption (Detmann *et al.,* 2009).

5.3 Performance and efficiency of supplement use: Substitutive effect occurs when supplement intake reduces forage intake. Despite being more intensely observed in energy supplementation (Souza *et al.,* 2010), the substitutive effect may occur when high levels of protein supplement is offered in a short period of time (Sampaio *et al.,* 2010b). Thus, substitution of forage nutrients by supplement nutrients might explain the lack of increase in performance of the animals with an increase in the level of carbohydrate intake (HPHC and LPHC), even when it was increased the jointly supplementation of carbohydrate and protein (HPHC). However, differently from the other phases, in phase 2 (dry season), high levels of jointly supplementation of carbohydrate and protein (HPHC) improve the performance. A plausible explanation is that in phase 2 the HPHC presented an appropriate balance of protein and energy, where occurred supplied of protein deficit of pasture with appropriate energy offer allowing an efficient utilization of protein (Souza *et al.,* 2010) and thus a greater availability of metabolizable energy and protein to animal. Protein supplementation implies changes in forage intake, availability of dietary energy, quantity of biochemical precursor for microbial and

animal metabolism and consequently, may determine animal performance (Detmann *et al.,* 2011).
Although the supply of high levels of carbohydrate could increase total energy intake, it did not improve performance. It is likely that the substitute effect caused by NFC intake reduced forage utilization (Souza *et al.,* 2010); thus, when ruminants are fed with high amount of NFC occur completion between fibrolytic and non-fibrolytic microbial species for essential nutrients (Carvalho *et al.,* 2011) and reduce fiber utilization (Costa *et al.,* 2008) in reason of lower growth rate of fibrolytic microbial than non-fibrolitic. Therefore, carbohydrate supplementation might cause a partial substitution of pasture intake by supplement intake (Table 3) with a small increase in the total energy available to animal. Supplementation improved the performance of suckling calves (phase 1). Multiple supplementation increases intake and digestibility of calves (Sampaio *et al.,* 2010a). Thus, it also increases the amount of nutrients and metabolizable energy that allows an increment of muscle and fat tissue deposition by the animal. Strategies such as creep feeding, which allows access of calves to concentrate at early stage, have been successfully been used to progressively reduce nutritional and social dependence of the calf on the cow (Enríquez *et al.,* 2011). Thus, one of the main reasons for performance improvement might be a better ruminal condition at an early stage of development, which allows a better grazing efficiency before and after weaning. In phase 1, all supplemented animals presented similar performance. Probably, all supplements were able to increase energy and nutrients intake of calves to appropriated levels. However, Sampaio *et al.,* (2010a) observed greater weight gain and nutritional characteristics of suckling calves that received protein-energy supplement than energy supplement (90 % corn) and protein supplement (85% soybean meal). Level of CP of forage in the dry season (phase 2) was very low (5.5 %) (Table 2). Therefore, the energy extraction from fibrous carbohydrate was limited by CP deficit to enzymatic systems of ruminal microorganisms (Sampaio *et al.,* 2009; Detmann *et al.,* 2009). Thus, animal performance increased when protein was supplied. However, performance improved when high levels of protein (HPHC and HPLC) were supplied. Adjustments of nutritional deficits of pasture by multiple supplementation, increases degradation rate (Oliveira *et al.,* 2010, Detmann *et al.,* 2011), decreases the discrete latency of NDF in rumen (Detmann *et al.,*, 2011) and increases of passage rate, and thus, increases the intake (Oliveira *et al.,* 2010) and the availability of digestible substrate to animal. Mateus *et al.,* (2011), when studying the effect of energy levels on steers in tropical pasture in dry season, found a quadratic effect on weight gain with the maximum point with 0.5 % BW (18.5 % CP). The total digestible nutrients (TDN) was not increased with supplement levels above 0.5%, and it likely that above this value the increase of supplement level was similar to reduction of pasture intake. In addition, Figueiredo *et al.,* (2011), when studying the effect of energy levels to heifers in tropical pasture in rainy season, found a positive linear effect on ADG without variation in DM intake, but TDN intake increased with level of supplementation. Thus, we may observe that supplements provide different responses in function of season or pasture quality. Although the pastures presented greater quality in dry-rainy transition season (phase 3) than in dry season (phase 2) (Table 2), the supplemented animals presented similar performance in both seasons. After the early rains, CP level of forage increase, but a significant part of this CP is in form of non-protein nitrogen. In addition, animals prefer to consume sprouts in detriment to mature part of plant, increasing grazing time, due to the increase in time spent selecting (Valente *et al.,* 2011). Thus, abrupt change of diet and behaviour usually impair the performance (Valente *et al.,* 2011). Traditionally, Brazilian producers believe that pasture presents great quality and it is able to appropriately supply the nutrients to cattle in rainy season and is not necessary the supplementation of the livestock. However, in this work, supplemented animals presented additional gain of 0.178 kg/day to non-supplemented animals, corroborating to Tonello *et al.,* (2011), who, in a metanalysis study of Brazilian works, found additional gains of 0.152 kg/day for supplemented animals. In the rainy season, tropical pasture presented energy/protein relationship higher than demanded by cattle, implying in a relative excess of energy in relation to protein (Detmann *et al.,* 2010). Therefore, protein supplementation may balance the energy/protein relationship for the metabolic requirement and improve performance. The supplementation as a function of nutritional requirement, which is in turn, determined by weight gain rate, allowed a low supplement level in periods when the pasture presented low potential to supply nutritional demands, and high level of supplement

when pasture presented high quality, thus it occurred high efficiency of supplement use.

It is likely that, in phases 1 and 2, the offer of multiple supplements were nearly to the level needed to supply the nutritional forage deficit and occurred a high efficiency of supplement use. However, in phases 3 and 4, the pasture presented high protein level (Table 2), thus the supplements acted to balance nutrients in the rumen and directly supply substrates to the animal, with a decrease in the efficiency of supplement use. Although it presented a lower efficiency in phases 3 and 4, multiple supplementations were important to increase weight gain rate and to allow slaughter of animals in the end of the rainy season, at 18 months of age.

6 CONCLUSION

Although non-supplemented animals present similar total dry matter intake in the rainy season, supplementation increases performance of young bulls in the productive cycle. However, nutritional plans that provide low amount of carbohydrate (until 15% of TDN requirements) have greater efficiency of supplement use.

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