Suplementação de Bovinos de Corte a Pasto

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Introduction

Flexible management of the grazing system is required to optimize animal performance and the use of supplementary feed can overcome the shortfalls of the forage component. When energy and protein requirements increase due to lactation, pregnancy, and growth, part of the forage component of the diet may need to be replaced by concentrates (Fontaneli, 1999). Cool- and warm-season forages have seasonal production due to climatic conditions, such as rainfall, temperature, and daylenght, and the use of supplements are necessary to maintain animal performance during those periods. In addition, forages tend to decrease nutritive value during the limited rainfall periods and supplementation may improve animal performance by supplying limiting nutrients.

Concentrates generally are more digestible than forages and have much higher fermentation rates. According to Stockdale et al. (1987), several factors may affect the response to supplement, including quality of the pasture and supplement, amount of pasture and supplement fed, and degree to which supplemental feeds replace pasture intake.

Considering that the term “supplement” means providing additional sources of feed to animals consuming the majority of the dry matter intake from forages, it is essential to have an accurate estimate of forage nutritive value to efficiently meet the animal’s requirements. The objective of this publication is to describe some methods to determine forage nutritive value and the most used supplementation programs used for grazing animals.

Methods to estimate digestibility of C4 grasses

Forage nutritive value is determined by nutrient concentration, nutrient digestibility, and nature of the digestion of the end products (Moot, 1959). Nutritive value should refer to inherent characteristics of consumed forage, which determine its energy concentration.

The differences in C4 grasses, in association with the effects caused by different management practices, pose a challenge to accurately estimating energy concentration of these plants. Cell walls (NDF) and their derivatives (ADF) have been used either alone or with other chemical entities, to predict both intake and digestibility (Moore et al, 1996). Van Soest (1967) developed the NDF analysis to estimate total cell wall and showed that cell wall contents met the criteria of a nutritive entity, but NDF did not because its highly variable digestibility (Moore, 1994). In addition, Van Soest (1967) proposed a summative equation for predicting digestible DM concentration of forages. Digestible NDF was determined from NDF concentration and the empirical prediction of NDF digestibility from ADF and lignin. Duble et al. (1971) found that the summative equation of Van Soest (1967) was not acceptable for tropical grasses.

Acid detergent fiber is used most frequently by U.S. feed testing laboratories to estimate digestibility. Reported correlations between concentrations of ADF and digestibility of OM and DM vary between -0.5 to -0.95 (Minson, 1982). According to Moore et al. (1999), published r values have ranged from -0.39 and -0.93 between DDM and ADF. The correlations with greater r between ADF and digestibility are found in cool-season forages or total mixed rations (TMR) but not in C4 grasses (Table 2). These authors concluded that routine forage testing programs only using ADF and NDF may often provide unacceptable of DMI and DDM, for both grasses and legumes. Several laboratories in the country developed their own equations to convert ADF in digestible dry matter and therefore the results may not be consistent across laboratories.

Table 2. Correlation between digestibility and ADF from the literature

Source	Forage	r
Van Soest, 1965	Alfalfa (11)	-.74
	C3 Grass (9 to 20)	-.73, -.74
	All (83)	-.74
Van Soest et al., 1978	Diverse (187)	-.75
Moore et al., 1998	C4 grasses	-.39

Adapted from Moore et al. (1999)

The DDM concentration of a stargrass and Mulato samples with known in vivo apparent dry matter digestibility (51 and 64%, respectively) were calculated based on its ADF concentration using formulas from different laboratories. There was a large variation in the estimated DDM between laboratories. It seems that the formulas were more accurate to estimate a sample with relatively low digestibility (stargrass) than the Mulato sample with greater digestibility (Table 3).

Table 3. Apparent dry matter digestibility of stargrass and Mulato samples compared with the estimate digestible dry matter calculated from ADF concentration using different laboratories (Vendramini 2010).

Forage species			Lab 1†	Lab 2	Lab 3	Lab 4	Lab 5	Lab 6	NFTA
	ADF	Apparent DDM	Estimate DDM						
	%	%	%						
Stargrass	45.0	51.0	44.2	48.6	53.8	51.2	56.7	48.6	53.8
Mulato	39.0	64.0	53.5	53.1	58.5	58.1	61.5	53.1	58.5

† Lab 1 = (6.107+3.994*ADF-0.066*ADF*ADF)-8

Lab 2 = 82.38-(0.7515*ADF)

Lab 3 = 88.9-(0.779*ADF)

Lab 4 = 4.898+(89.796*(1.0876-(0.0127*ADF)))

Lab 5 = 34.9+(53.1*(1.085-(0.015*ADF)))

Lab 6 = 82.38-0.7515*ADF

NFTA = 88.9 - 0.779*ADF

There is a consensus in the scientific community that no other single laboratory technique predicts digestibility as well as the in vitro procedure. The in vitro procedure is widely used because it measures two nutritive entities: cell contents and digestible cell walls. The in vitro procedure has large capability and it is considered a precise method and was used first for ranking forage. The major advance in vitro technique came of the two-stage procedure proposed by Tilley and Terry (1963) and the method had many derivations since then. Many studies have shown a strong correlation between the in vivo and in vitro digestibility data (Weiss, 1994) when ruminants were fed all forage diets. However, it may be still necessary to develop a calibration equation to convert IVDMD to in vivo digestibility. The equations present in the literature should not be adopted directly by other laboratories because of many confounding variables within laboratory. Instead, each laboratory should generate its own equation. In order to maintain the consistency among runs, standards should be included in each run. Ayres (1991) stated that when the IVDMD of the standard is outside 95% confidence interval, the run can be corrected based on the deviation of the standards.

The main source of variation in the in vitro procedure is the rumen fluid collected from the donor animal; therefore, it is not realistic to expect similar results from in vitro procedures conducted in different laboratories because the donor animal has likely been fed different diets. Nelson et al. (1972) reported that when bermudagrass was fed to donor animals, IVDMD values for a variety of forages were higher than when perennial ryegrass (*Lolium perenne*) was fed, but when another warm-season grass (bahiagrass, *Paspalum notatum*) was fed, the IVDMD values were less than when perennial ryegrass as fed. The laboratory needs to identify the type of samples that will be analyzed and adapt the diet of the donor animal, but no single donor diet will produce accurate results for all possible test forages (Weiss, 1994).

Neutral detergent fiber digestibility (NDFD) has been another predictor of forage digestibility and has evolved from a research evaluation to a common commercially available value. Vendramini et al. (2010) noted a correlation of NDFD and IVTD in nine species and cultivars of warm-season grasses (r = 0.88). Mertens (2009) proposed that DMD = 85.1 – (0.98 – NDFD) x NDF for animals receiving TMR. Reported NDFD values are only relevant within procedures, and even then have questionable relationship to animal models (Ward, 2009).

There are no standard procedures for NDF or NDFD, which results in a large variation in values among laboratories.

The NIRS has been used widely to provide estimates of CP, ADF, NDF, and in vitro digestion. Norris et al., (1976) demonstrated that NIRS could also be used to estimate animal intake. The problem with predict chemical composition and intake measurements from NIRS has been the necessity of obtaining sufficient number of samples coming from defined management conditions. The differences among C4 grasses species and cultivars, in addition to the effects of management practices in forage nutritive value, pose a challenge for commercial laboratories to have calibration equations that will provide accurate results for a range of C4 grasses under different management practices.

Interactions between Supplements and Forages

When forages are offered free choice and supplemental concentrates are offered in restricted amounts, forage dry matter intake may either increase, decrease, or remain the same (Moore, 1992). In many cases, animal responses to supplements are either greater or less than expected. The deviations between expected and observed performance are usually explained by associative effects of supplements upon voluntary intake and digestibility of the total diet (Moore et al., 1999). In general, concentrates will decrease forage intake when forage quality is high, other nutrients are in balance with energy, and concentrate is fed in large amounts. Large differences in substitution rates have been reported and the effects have greater relation to differences among forages rather than to differences among concentrates (Waldo, 1986). On the other hand, small amounts of concentrate may increase voluntary intake when forages nutritive value is low, especially when the forage has a high ratio of TDN to CP (Moore, 1994).

Sarker and Holmes (1974) fed supplement in increments of 2, 4, 6, or 8 kg OM/d to non-lactating cows grazing ryegrass. Although total OMI increased with increasing amounts of concentrate, the average increase in forage intake was 0.46 kg OM/kg of concentrate OM fed. Meijs (1986) fed high-starch supplements or high fiber supplements to cows grazing predominantly perennial ryegrass swards. Supplement intake was 5.5 and 5.3 kg OM/d with forage intakes of 11.5 and 12.6 kg OM/d for high and low starch treatments, respectively.

Average forage substitution rate for animals receiving supplements was 0.45 vs. 0.21 kg herbage/kg concentrate for animals receiving starch and fibrous supplements, respectively. Royes et al. (2001) evaluated different sources of energy (maize, sugar cane molasses, or soybean hulls) and feeding rates (0, 1.4, or 2.8 kg DM/steer/d in growth trials; 0, 15, or 30% of the ration DM in digestion trials) of supplements fed to cattle receiving ammoniated stargrass (*Cynodon nlemfuensis*) hay. Increasing the level of supplementation decreased hay intake but increased total dietary intake for all diets. Daily gain and feed efficiency of steers improved with supplementation. Steers supplemented with corn or soybean hulls at 2.8 kg DM/d had a higher ADG (0.92 kg) and gain:feed (0.103) than steers supplemented with molasses (0.78 kg) at the same level.

According to Galloway et al. (1992), moderate dietary levels of supplement (20-30%) can improve nutrient intake and performance by cattle consuming bermudagrass (*Cynodon dactylon*). At greater amounts, nutrient digestion, intake, or both, of the forage portion of the diet can be affected negatively. Cattle grazing forages with DOM:CP ratios greater than seven to eight are likely to have inadequate ruminally degradable protein and should respond to N supplemention by increasing intake and animal performance (Moore and Kunkle, 1999). Wheeler et al. (2002) tested the effects of increasing supplement protein concentration on performance and forage intake of beef steers consuming bermudagrass forage. Treatments were no supplement or daily equivalents of 0.2, 0.4, and 0.6 g of supplemental protein/ kg of BW. Forage intake increased 16% and total OMI increased 30% in supplemented compared to unsupplemented steers. Diet OM digestibility increased 14% in supplemented compared to unsupplemented steers.

A special case of substitution and associative effects is the use of total mixed rations (TMR) for lactating dairy cows. Such diets may include several sources of forage and combinations of concentrates. Because TMRs often are based on high quality forage and include high percentages of concentrates, intake and digestibility of the forage component is very likely less than expected when forage is fed alone (Moore, 1994). Fike et al. (2003) studied the effects of two levels of supplementation on forage and total intake of lactating dairy cows grazing bermudagrass and rhizoma peanut (*Arachis glabrata*) pastures. The substitution of forage OM by supplement OM (kg/kg) was 0.48 for rhizoma peanut and 0.06 for bermudagrass. Feeding additional supplement increased total OMI by 23 and 0.9% for cows grazing bermudagrass and rhizoma peanuts pastures, respectively.

Protein Supplementation

Microbial protein is a major protein source for ruminants; therefore, optimizing microbial protein synthesis is essential. In a review of protein supplementation of grazing livestock, Petersen (1987) stated that enhanced forage utilization occurs in several ways. Protein supplements provide amino acids, carbon skeletons, and minerals that help satisfy microbial requirements, thereby increasing microbial growth and/or fermentation. These factors combine to increase intake through increased microbial activity and rate of passage (Allison, 1985). In addition to increasing available nutrients in the rumen, protein supplements may also increase the quantity of protein reaching the small intestine through undegraded or bypass protein.

Crude protein concentration of high nutritive value herbage may exceed 25%, however, 65% to 85% of total protein is degradable in the rumen, with 15 to 35% escaping the rumen. Vendramini et al. (2008b) observed that a rye (*Secale cereale* L.)-annual ryegrass (*Lolium multiflorum*) mixture had, on average, 18% of CP and 71% of IVDOM during the growing season (from January to May). In addition to the high levels of CP present in the cool-season forage, Vendramini et al. (2008a) found that approximately 70% of the CP of annual ryegrass is potentially degraded in the rumen (Fractions A and B, Fig. 1). According to Poppi and McLennan (1995), calves grazing high quality cool-season pasture may have high ammonia losses if forage CP concentration exceeds 15%. The loss of N from the rumen is costly due to significant energetic expenditure associated with urea synthesis and excretion. The high levels of rumen-degradable protein in cool-season forages indicate that supplements containing readily available carbohydrates and rumen-undegradable protein should be considered for early weaned calves grazing cool-season pastures (Vendramini et al., 2006).

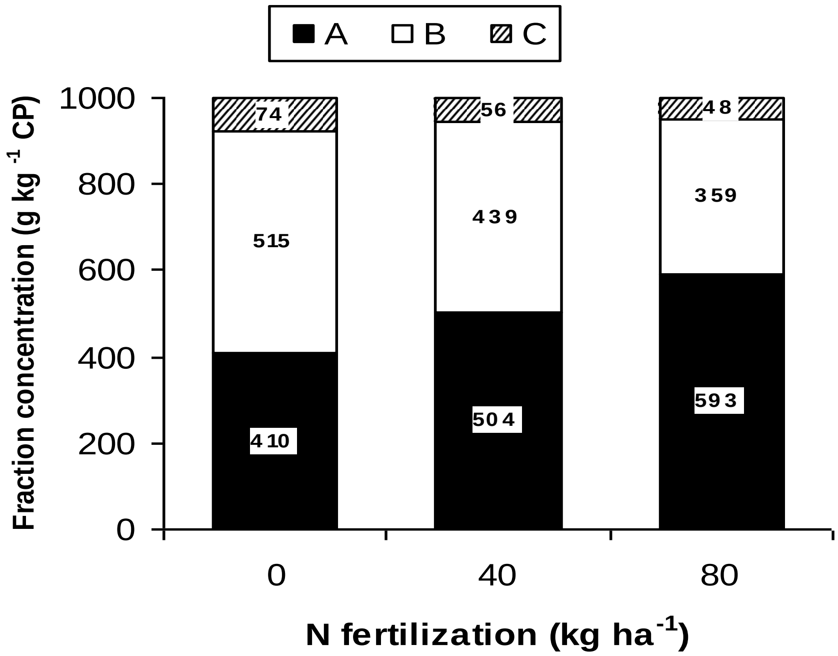

Fig. 1. Nitrogen fertilization effects on crude protein (CP) fraction concentrations in total CP of rye–ryegrass herbage. There was a linear increase in Fraction A ($P < 0.01$, $\mathrm{SE} = 28$), and a linear decrease in Fraction B ($P < 0.01$, $\mathrm{SE} = 23$) and Fraction C ($P < 0.05$, $\mathrm{SE} = 12$) as N fertilization level increased.

Vendramini et al. (2011) tested three levels of RUP supplementation, 0.15 % BW of soybean meal (44% CP, 35% RUP), 50:50 mixture soybean meal-soyplus (44% CP, 47.5% RUP), or soyplus (44% CP, 60% RUP) on early weaned calves grazing annual ryegrass in Florida. There was a linear increase in herbage mass (from 1.9 to 2.1 Mg/ha) and herbage allowance (from 1.1 to 1.4 kg DM/kg LW) on pastures grazed by calves receiving increasing levels of RUP, however, there was no difference in calf' average daily gain (0.76 kg/d) among treatments. Increased RUP supplementation decreased forage dry matter intake and total dry matter intake in one of experimental years (Table 1).

Table 1. Forage DM intake (FDMI), total DM intake (TDMI), and apparent DM digestibility (ADMD) of diets fed to early weaned calves receiving annual ryegrass and three levels of rumen-undegradable protein in 2008.

	Treatments†				
Response variable	SBM (35% RUP)	SBMSP (47% RUP)	SP (60% RUP)	Polynomial Contrast‡	SE
FDMI (% BW)	2.2	2.0	1.7	Linear	0.2
TDMI (% BW)	3.2	3.0	2.7	Linear	0.2
ADMD (%)	62	66	64	NS	42

† SBM = soybean meal, SPSBM = 50:50 mixture of Soyplus® and soybean meal, SP = Soyplus®
‡Linear ($P < 0.10$), NS = not significant ($P > 0.10$)

Non-structural carbohydrates are needed to utilize the forage N in the rumen, to reduce energy cost of excreting N, and to supply nutrients to the small intestine. Microbial protein synthesis can become a performance-limiting factor for ruminants consuming highly digestible ryegrass diets. Hill (1991) observed that in young calves grazing ryegrass, synthesis of microbial protein was 6 to 10 g 100/g of OM digested in the rumen, and energy/protein supplements increased the flow of microbial and undegraded dietary protein to the intestines, and increased forage intake proportionally. In a study with beef steers grazing rye-ryegrass pasture and receiving free-choice mineral, Grigsby et al. (1991) compared corn meal and fish meal concentrates. Average daily gain was 1.5 and 1.0 kg/d for corn meal and fish meal, respectively. Supplemental energy may have provided a source of rapidly fermentable carbohydrate, which was well synchronized with ammonia and peptide production from forage protein degradation, which in turn may have resulted in a greater synthesis of microbial protein. Moore et al. (1999) suggested that the ratio of digestible organic matter (DOM) to CP should be no more than seven to one based on the observation that animals consuming forages with ratios greater than seven were likely to respond to CP supplement.

Hill et al. (1990) studied beef heifers grazing ryegrass pastures (24% CP) and supplemented with maize, cottonseed meal, blood meal, feather meal, fishmeal, or condensed molasses with cottonseed meal. Meal-based supplements were given at 0.35% of body weight (DM basis). Forage organic matter intake (OMI) (65% digestible) was increased by blood and fishmeal supplements and decreased by cottonseed and feather meal. It was concluded that blood and fish meal seemed to be more effective in supplying required protein and essential amino acids that stimulate intake of forage.

In C4 grasses, protein may be excessive or seriously deficient, depending on the pasture species, season, and maturity of growth (Poppi and McLennan, 1995). Minson (1990) compiled a series of studies in which CP was below 6 % in the base forage. There was an average 40% increase in intake due to protein supplement and a 34% increase due to supplementary urea. Probably, the greatest and most uniform response to supplemental N occurs when the CP concentration of the base forage is below 7% (Coleman et al., 2004). Bodine et al. (1999) reported the effect of four sources of ruminal degradable protein and two sources of energy supplementation on steers consuming low-quality hay (< 70 g CP/kg OM). Forage OMI and total OMI increased quadratically as rumen degradable protein increased for both energy supplements. When DOM:CP ratios of limpograss [*Hemarthria altissima* (Poir.) Stapf and Hubb.] were between 8 and 10, cattle responses to CP supplementation were significant (Lima et al., 1999). Vendramini and Arthington (2010) evaluated the effects of protein supplementation on heifers grazing stockpiled limpograss pastures during the winter in Florida. Treatments were three cottonseed meal supplementation levels, 0 (control), 1.1, and 2.2 kg/head/d, or heifers grazing part-time annual ryegrass. The CSM contained 48% CP and 69% TDN. The concentrate was fed three times per week, Monday, Wednesday, and Friday. There was no difference in average daily gain of heifers part-time grazing ryegrass or supplemented with 2.2 kg/ head/d; however, 2.2 kg/ head/d provided greater gain per ha (Table 2). Despite of similar ADG, the heifers part-time grazing annual ryegrass had lesser blood urea nitrogen concentrations (Table 2).

Table 2. Response of heifers grazing stockpiled limpograss supplemented with three levels of cottonseed meal or part-time grazing annual ryegrass averaged across years.

Treatment[†]	Animal Response[§]		
	Average daily gain	Liveweight gain	BUN
	kg/d	kg/ha	mg/dL
CSM0[‡]	0.14 c	70 c	21.2 bc
CSM1	0.44 b	221 b	23.1 b
CSM2	0.64 a	322 a	27.3 a
PTG	0.67 a	188 b	19.2 c
P value	< 0.01	< 0.01	< 0.01
SE	0.06	27	0.8

Treatment means within a column (response variable) followed by the same lower case letter are not different (*P* > 0.10)

[‡] CSM0 = control, CSM1 = 1.1 kg CSM/head/d, CSM2 = 2.2 kg CSM/head/d, and PTG = part-time grazing annual ryegrass

[§] Values presented are averages of 2 yr

Hammond et al. (1994) suggested assessing blood urea N (BUN) concentrations as a method to monitor the need for supplements by grazing animals when forage nutritive value data are not available. Cattle BUN concentrations from 9 to 12 mg/dL are considered to be a transition range below which gain response to protein supplementation has been positive. Hoffman et al. (1993) reported a summary of BUN values from several studies with dairy cows. There was an apparent excess of N in the rumen in relation to carbohydrates and wastage of highly degradable N in pasture forage when BUN values ranged from 18.5 to 28.6 mg/dL. Newman et al. (2002) observed higher BUN concentrations (18 vs. 15 mg/dL) on heifers grazing limpograss either with or without CP supplementation, respectively.

Energy supplementation

Energy supplements for forages generally fall into three categories: starch, sugars, and fiber (Poppi and McLennan, 1995). Sources of fibrous highly-digestible energy, such as soybean hulls or wheat middlings, have shown the most consistent response, presumably because of the good synchrony with NH_3 released (Poppi and McLennan, 1995). Johnson et al. (2001) supplemented mature cows on bermudagrass pastures with soyhulls or corn at 0.17% BW. There was no difference in dry matter intake (DMI) or ADG between the treatments. These results suggest that low levels of corn supplementation did not affect forage intake and animal performance. Supplementing forage with a starch source, especially at levels > 25% of the total DM tends to reduce fermentation of the basal forage [Goetsch et al. (1991), cited by Coleman et al. (2004)]. According to Fieser and Vanzant (2004), when fed at similar levels of OM, soybean hull supplementation provided an average of 6% greater DOM intake than corn supplementation. Vendramini and Arthington (2009) tested soybean hull supplementation at 0, 1.6, or 3.2 kg DM/cow daily, additional to a base supplement of 1.6 kg of liquid molasses and 0.8 kg of cottonseed meal. Pastures with cows receiving no supplemental soybean hulls had a greater decline in herbage mass (1,490 to 960 kg DM/ha) than pastures with cows receiving soybean hulls (1,640 to 1,250 kg DM/ha). Cow ADG, body condition score change, milk production, and calf ADG increased linearly as the rate of soybean hull supplementation increased (Table 3). Forage DMI decreased as soybean hull supplementation level increased (Table 4).

Table 3. Average daily gain, BCS change and milk production of primiparous beef cows grazing bahiagrass pastures and receiving three levels of soybean hull supplementation

Treatment[1]	ADG (kg/d)	BCS change	Milk production (kg/d)	Calf' ADG (kg/d)
Control	-0.05	-0.65	4.3	0.66
Medium	0.01	-0.44	5.5	0.76
High	0.10	-0.07	6.6	0.88
Polynomial contrast	Linear *P*<0.01	Linear *P*=0.02	Linear *P*<0.01	Linear *P*=0.08
SE	0.09	0.20	1.6	0.26

[1]Treatments consisted of three levels of soybean hulls, 0, 1.6, and 3.2 kg/head daily, constituting a control, medium, and high level of supplementation, respectively. All treatments were additional to 1.6 kg of liquid sugarcane molasses and 0.8 kg of cottonseed meal/cow daily. Supplements were offered three times weekly (Monday, Wednesday, and Friday) for 114 d starting at an average of 64 ± 20 d prior to calving.

Table 4. Total DMI and forage DMI of primiparous beef cows receiving stargrass hay supplemented with three levels of soybean hull supplementation

Treatment [1]	Total DMI	Forage DMI
	---------------(% BW)---------------	
Control	2.59	1.95
Medium	2.85	1.81
High	2.80	1.58
Polynomial contrast	Linear	Linear, Quadratic
	P<0.01	*P*<0.01
SE	0.05	0.06

[1]Treatments consisted of three levels of soybean hulls, 0, 1.6, and 3.2 kg/cow daily, constituting a control, medium, and high level of supplementation, respectively. All treatments were additional to 1.6 kg of liquid sugarcane molasses and 0.8 kg of cottonseed meal/cow daily. Supplements were offered to cows for 114 d starting at an average of 64 ± 20 d prior to calving. Calves were weaned from cows at an average of 77 ± 20 d of age.

Ordonez-Tercero et al. (2003) used two energy sources [sugar-cane (*Sacharum officinarum*), molasses and maize] to test the effect of energy supplementation on intake and digestibility of the basal diet elephantgrass (*Pennisetum purpureum*) and a foliage mix of *Brosimum alicastrum* and leucena (*Leucaena leucocephala*). There were no differences in basal diet intake (5.5 kg DM/d) among treatments. The potentially degradable DM (34%) and OM (36%) fractions were not affected by energy supplementation. Frizzo et al. (2003) studied the effect of levels of energy supplementation on the productive and reproductive performance of Charolais heifers maintained in a cultivated pasture of black oat (*Avena strigosa*) plus annual ryegrass. It was shown that supplementation increased ADG, stocking rate, and LWG. Heifers kept only on pasture had lower body condition and showed lower estrus percentage than heifers supplemented with 0.7 and 1.4% of LWG/d. The estimated intake of DM was lower for the 1.4% BW/d supplementation level. In South Brazil, Rocha et al. (2003) evaluated performance of beef heifers grazing oat-annual ryegrass mixtures with and without ground maize supplement. The utilization of oat and ryegrass pasture with supplementation resulted in higher ADG, stocking rate, and LWG than the mixture with no supplement. Vendramini et al. (2006) tested the effects of increasing levels of energy supplements on early weaned calves grazing rye-annual ryegrass. There was an increase in ADG and stocking rate, and a decrease in forage organic matter intake. However, the total organic matter intake was not affects by the treatments.

Table 3. Responses of early weaned calves grazing rye-ryegrass pastures and supplemented with different levels of concentrate. Data are means across 2 yr.

	Concentrate (% BW)			Polynomial contrast†	SE
Calf response	1	1.5	2		
Average daily gain (kg)	0.74	0.81	0.89	L, $P < 0.01$	0.03
Stocking rate (AU/ ha) ‡	5.5	5.9	6.5	L, $P < 0.01$	0.1
Liveweight gain (kg/ha)	950	1080	1320	L, $P < 0.01$	42
Total OMI§ (% BW)	2.6	2.4	2.7	$P \geq 0.11$	0.02
Forage OMI§ (% BW)	1.8	1.3	1.1	L, $P < 0.01$	0.01
Grazing time (min)	284	230	234	L, $P = 0.015$; Q, $P = 0.08$	17
BUN¶ (mg/dL)	14.1	15.1	13.0	$P \geq 0.26$	1

†L = linear; Q =quadratic
‡AU = animal unit (500 kg liveweight$^{0.75}$)
§OMI = organic matter intake
¶Blood urea nitrogen; data from 2004 only.

Araujo et al. (2010) tested the effects of rumen-protected PUFA (polyunsaturated fat acids) on performance of beef heifers on pastures in Florida. The supplements were isonitrogenous and isocaloric with no rumen protected PUFA or with the inclusion of rumen-protected PUFA as 5.2% of the supplement (total supplement intake = 2.5 kg/animal/d). There was no difference in animal performance (~ 0.42 kg/d). Islas et al. (2010) supplemented beef steers grazing wheat (*Triticum aestivum*) pastures with 0.5% BW of soybean hulls and wheat middlings or the same supplement with the addition of 0.12% BW of yellow fat. There was no difference in ADG between treatments (~ 1.27 kg/d). Scholljegerdes and Kronberg (2010) observed that there was no difference in ADG (0.79 kg/d) between beef steers grazing summer native pastures and receiving isonitrogenous and isocaloric supplements containing corn, soybean meal, and molasses or flaxseed and molasses. The effect of fat supplementation on performance of grazing ruminants is not abundantly reported in the literature and further studies are necessary to evaluate the efficiency of this management practice.

Conclusions

Supplementation is an effective management practice to maintain animal performance of grazing animals during the periods of limited forage quantity and/or quality. The supplementation program must optimize the use of the forage resource; therefore, an accurate estimate of forage nutritive value is necessary to design an effective supplementation program. The decision of the quantity and types of supplement should be decided based on the enterprise objectives and economic feasibility.

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