Revista Brasileira de Zootecnia
© 2009 Sociedade Brasileira de Zootecnia
ISSN 1516-3598 (impresso)
ISSN 1806-9290 (*on-line*)
www.sbz.org.br

R. Bras. Zootec., v.38, n.7, p.1347-1354, 2009

Body composition and energy and protein requirements of grazing Nelore steers[1]

Vitor Visintin Silva de Almeida[2], Augusto César de Queiroz[3], Fabiano Ferreira da Silva[4], Robério Rodrigues Silva[5], Aline Cardoso Oliveira[2], Danilo Ribeiro de Souza[6]

[1] Projeto financiado pelo Banco do Nordeste do Brasil/FUNDEC.
[2] Programa de Pós-graduação em Zootecnia - UFV.
[3] DZO/UFV, Viçosa, MG.
[4] DTRA/UESB, Itapetinga, BA.
[5] DEBI/UESB, Itapetinga, BA.
[6] Universidade Estadual do Sudoeste da Bahia - UESB.

ABSTRACT - This experiment was carried out with the objective of determining the energy and protein requirements of grazing Nellore steers. Twenty four Nellore steers (average 371 ± 14 kg of BW and 26 months old) were used. Four steers were slaughtered at the beginning of the experiment (reference group), serving as a reference for the subsequent study. The remaining 20 animals were weighed and distributed in a randomized complete block design with four levels of supplementation offers: 0.0 (mineral mixture - control), 0.3, 0.6 and 0.9% BW, with five replications. The supplements, based on ground corn, soybean meal and/or urea, were previously balanced to achieve an average daily gain of 350, 650 and 850g, respectively, for the different levels of supplementation offers. The protein, fat and energy contents retained in the animal body were determined by regression equations of the logarithm of the protein, fat and energy in the animal body contents, in function of the logarithm of empty body weight (EBW). Net requirements of protein and energy for a gain of 1kg of EBW were obtained by deriving the prediction equations of the animal body content of protein, fat, or energy in function of the EBW logarithm. The net energy requirements for weight gain of Nellore steer can be obtained by the equation: $NEg = 0.05764 \times EBW^{0,75} \times DEBWG^{0.8328}$. The following equation was obtained to estimate the retained protein (RP), in function of the average daily gain (ADG) and retained energy (RE): RP = 28.9199 + 85.7301 FBWG + 8.0669 RE. The net protein requirement for Nellore steers decreased as the body weight increased, with values of 174.62 and 163.10 g/kg EBG for animals of 300 and 450 kg BW, respectively.

Key Words: energy, protein, requirements, zebu cattle

Composição corporal e exigências energéticas e proteicas de bovinos Nelore castrados em pastejo

RESUMO - Com o objetivo de determinar as exigências de energia e proteína de novilhos Nelore sob pastejo, foi conduzido um experimento utilizando 24 novilhos da raça Nelore, castrados, com peso inicial de 371 ± 14 kg e 26 meses de idade. Quatro novilhos foram abatidos no início do experimento (grupo referência) para servir de referência nos estudos subsequentes. Os animais restantes (20) foram pesados e distribuídos em delineamento inteiramente casualizado com quatro níveis de suplementação: 0,0 (mistura mineral - controle); 0,3; 0,6 e 0,9% do PC e cinco repetições. Os suplementos, à base de milho, farelo de soja e/ou uréia, foram balanceados previamente para promover ganhos médios diários de 350, 650 e 850 g, respectivamente. Os conteúdos de proteína, gordura e energia retidos no corpo foram estimados por meio de equações de regressão do logaritmo do conteúdo corporal de proteína, gordura ou energia, em função do logaritmo do PCVZ. Derivando-se as equações de predição do conteúdo corporal de proteína, gordura, ou energia em função do logaritmo do PCVZ, foram obtidas as exigências líquidas de proteína e energia, para ganho de 1 kg de PCVZ. As exigências de energia líquida para ganho de peso de zebuínos castrados podem ser obtidas pela equação: $ELg = 0,05764 \times PCVZ^{0,75} \times GDPCVZ^{0,8328}$. Foi obtida a seguinte equação para estimativa da proteína retida (PR), em função do GMD e da energia retida (ER): PR = 28,9199 + 85,7301 GPVJ + 8,0669 ER. A exigência líquida de proteína para animais Nelore castrados diminui com o aumento do peso vivo e corresponde a 174,62 e 163,10 g/kg GPCVZ em animais de 300 e 450 kg de peso vivo, respectivamente.

Palavras-chave: energia, exigências, proteína, zebuínos

Received July 16, 2008 and accepted February 17, 2009.
Corresponding author: vsazootec@yahoo.com.br

Introduction

Beef cattle production in Brazil is largely based on pasture system conditions and is characterized as extensive production. Because of this, it is necessary to establish feeding standards for animals reared in these conditions. Knowledge of nutritional requirements is extremely important to formulate diets that meet the needs of animals, optimizing their genetic potential without wasting nutrients.

The net energy system, developed by Lofgreen & Garrett (1968), is the basis of the NRC (2000), a widely adopted model for the formulation of diets for beef cattle, that is also used in Brazil. The system splits the net energy requirements into net energy requirements for maintenance and weight gain (growth and fattening). The sum of the needs for maintenance and gain represents the animal net energy requirements.

Fontes (1995), in a pooled analysis of several experiments, observed differences in body composition and energy gain between castrated (steers) and intact animals (young bulls), so the net requirements for gain were different, thus the nutritional requirements of beef cattle should be set separately for steers and young bulls animals. However, when research data, developed in Brazil, is analyzed, it appears that most of the work involving the determination of beef cattle nutritional requirements was carried out with young bulls.

The net protein requirements for growing and finishing cattle depend on the dry fat-free content in weight gain, and they vary with breed, sexual condition and weight gain rate. As a result of this change in content of the gain, the net requirements of protein for gain are higher in young bulls than in steers, and in late maturity than early maturity of beef cattle animals (Geay, 1984), because young bulls deposit more lean tissue in the body than steers (Vanderwert et al., 1985).

Most of the information about nutritional requirements in Brazil comes from experiments with animals reared in feedlot confinement. Although it is the base of Brazilian livestock, the number of studies on the nutritional requirements of beef cattle on pasture is very limited.

The objective of this study was to determine body composition and energy and protein requirements of Nellore steers in a pasture based system.

Material and Methods

The experiment was conducted between August 2006 and February 2007. An area of 52.0 ha, composed of *Brachiaria brizantha* cultivar Marandu was split into eight paddocks of approximately 6.5 ha each, in a pizza design, with a drinking water source in the center.

Twenty four Nellore steers were used with average of 371 + 14 kg of body weight (BW) and 26 months of age. Four steers were slaughtered at the beginning of the experiment (animal reference group), serving as a reference in subsequent study. The remaining 20 animals were weighed and distributed in a randomized complete design with four levels of supplementation offer: 0.0 (mineral mixture – control), 0.3; 0.6 0.9% of BW and five replications, supplements, based on ground corn and soybean meal and/or urea, were previously balanced to achieve average daily gains (ADG) of 350, 650 and 850g, respectively, for the different levels of supplementation offer (Table 1).

Supplements were daily fed at 10 a.m. during the dry season, from August to November17, 2006. From November 18, 2006, the beginning of the rainy season, until February 26, 2007, the steers were kept under the same feeding regime, ad libitum fed only a mineral mixture until they reached the established slaughter weight of 450 kg.

The fecal output was estimated using chromic oxide (Burns et al., 1994) and was calculated based on the following equation FO = COO/CCP, where FO is the daily fecal output (g/day), COO is chromic oxide offered (g/day) and COF is the chromic oxide in the feces (g/g DM). The chromic oxide was provided in a single daily dose (10 g/animal) wrapped in paper packs and introduced directly through an applicator in the esophagus of the animals for 12 consecutive days, seven days for adaptation and regulation of marker excretion flow and five days of feces collection.

Samples of forage, feces and supplements were incubated in the rumen of four fistulated animals for 144 hours, to determine the internal marker (IM), the indigestible acid detergent fiber (iADF).

Estimates of individual voluntary intake were obtained using iADF in the following equation: $DMI = \{[(FO * IM_f) - IM_s] /) IM_{fo}\} + DMIS$, in which DMI is dry matter intake (kg/day), FO is the fecal output (kg/day); IM_f is IM in feces (kg/kg),and IM_s is IM in supplements (kg/day) and IM_{fo} is

Table 1 - Composition in ingredients of the supplement offers (% of DM)

Ingredient (%)	Level of supplement offer (% BW)			
	0 (control)	3	6	9
Corn meal		89.98	95.11	87.98
Soybean meal				10.40
Urea		5.00	2.44	0.06
Mineral mixture[1]	100	5.02	2.45	1.56

[1] Compostion: Ca, 18,5; P, 9; Mg, 0,4; S, 1 and Na, 11,7%; Se, 30, Cu, 1500; Zn, 4000; Mn, 1200; I, 150; and Co, 150 ppm.

IM in forage (kg/kg) and DMIS is DMI of supplements (kg/day). To determine total digestible nutrients (TDN) values, the total carbohydrates (TC) were estimated using the following equation: TC = 100 - (% CP + % EE + % ash) (Sniffen et al., 1992), while the non-fiber carbohydrates (NFC) were estimated by the difference between TC and neutral detergent fiber (NDF). Thus, TDN values were obtained by the equation TDN = DCP + DNDF +DNFC + (2.25 × DEE), in which DCP, DNDF, DNFC and DEE means, respectively, intakes of digestible CP, NDF, NFC and EE, which were obtained by the difference between their concentrations in the ingested diet and feces. The TDN intake was estimated multiplying the total DM intake by levels of TDN.

The nutritional composition of forage and supplements were determined using procedures described by Silva & Queiroz (2002) (Table 2).

The animals were weighed at the beginning and end of the experiment, and were also weighed every 28 days to adjust the supplement supply. The weighings were preceded by feed fasting of 16 hours. The animals were slaughtered at the pre-established slaughter weight of 450 kg of BW. After slaughter, the gastrointestinal tract was weighed, and its weight was added to the organs and other animal body parts (carcass, head, leather, tail, feet and blood), to determine the empty BW (EBW). The EBW and BW ratio of the reference animals were used to estimate the initial EBW of the animals that remained in the experiment. An animal from each level of supplement offer was randomly choosen to represent the group, and samples was taken from the head, feet (one anterior and one posterior) for subsequent physical separation of muscles, fat, bone and leather.

Blood samples were taken immediately after slaughter, placed in a glass bottle and taken to an air forced oven, at 55-60 °C for 48 to 72 hours, to determine the dry matter (DM) content, and then ground in a ball mill and kept in suitable containers for subsequent analysis, according to Silva & Queiroz (2002).

The carcass of each animal was divided into two halves, weighed, and then cooled in a cold chamber at -5 C for 18 hours. After this time, samples from the left half-carcass were collected and weighed, corresponding to the 9th to 11th ribs section (HH section) for further dissection and prediction of the proportions of muscles, bones and fat in the carcass, according to the equations recommended by Hankins and Howe (1946): Muscle, Y = 16.08 + 0.80 X; Adipose tissue, Y = 3.54 + 0.89 X and Bone, Y = 5.52 +0.57 X, where, X = percentage of components in the HH section.

A representative sample from each component was collected for the direct determination of total nitrogen and ether extract levels in the carcass.

Samples of rumen, reticulum, omasum, abomasum, small intestine, large intestine, internal fat, mesentery, liver, heart, kidneys, lungs, tongue, spleen, meat and industrial scraps (esophagus, trachea and reproductive system) were proportionally grouped forming a composite sample of organs + viscera.

Except for the blood samples, the composite samples of organs + viscera + (200 g) muscle and fat from the carcass (200 g of each), were ground and the leather (100 g), carcass bones, head and feet (200 g each), and tail (100 g), after sawing, were placed in a 500 mL glass bottle and put in an drying oven at 105ºC for a period of 48 to 96 hours, depending on the sample, to determine the fat content in dry matter (FDM). Subsequently, the samples were subjected to successive washings with petroleum ether, resulting in the pre-defatted dry matter (PDDM). Then, the samples were ground in a ball mill for subsequent analysis of total nitrogen and ether extract according to Silva & Queiroz (2002). Fat and protein contents in the animal body were determined according to the percentage concentrations of these in the organs, viscera, leather, blood, tail, head (muscle, fat and bone), feet (tendon and bone) and separate constituents

Table 2 - Nutritional composition of Brachiaria grass and supplements (% of DM)

Nutrient (%)	Brachiaria grass		Level of supplement offer (%BW)		
	Dry season	Rainy season	3	6	9
Dry matter	67.93	54.00	71.35	75.87	78.9
Organic matter	93.90	93.70	93.93	94.74	95.33
Crude protein	6.09	7.20	8.28	8.99	9.16
Ether extract	2.20	2.20	2.39	2.67	2.93
Total carbohydrates	85.61	84.30	83.26	83.08	83.23
Non-fibrous carbohydrates	1.31	3.50	8.58	20.55	29.15
Neutral detergent fiber	84.30	80.80	74.68	62.53	54.08
Acid detergent fiber	46.00	42.70	40.41	33.30	28.59
Total digestible nutrients	61.01	63.72	63.02	66.99	70.36
Ash	6.10	6.30	6.07	5.26	4.67

(fat, muscle and bone) of the HH section. The percentage of protein of the carcass was calculated by multiplying the physical composition of the carcass (estimated by the HH section) by the chemical composition of the constituent HH section (muscle, bone and fat). The determination of the energy in the animal body was obtained from the body content of protein and fat and their caloric equivalent, according to the equation recommended by the Agricultural Research Council (ARC 1980):

$EC = 5.6405\,X + 9.3929\,Y$, where: EC = energy content (Mcal), X = body protein (kg) and Y = body fat (kg).

Regression equations of the logarithm of the animal body content of fat, protein and energy, in function of the empty body weight (EBW) logarithm were used to predict the net amounts of protein, fat and energy retained in the animals body of each level of supplement offer, and all together, according to the following model (ARC, 1980): $Y = a + bX + e$, where, Y = logarithm of the total protein content (kg), fat (kg) and energy (McaL) retained in the empty body, a = constant, b = regression coefficient of the protein, fat, or energy logarithm, in function of the EBW logarithm; X = logarithm of EBW; e = random error.

For each level of supplement offer, the equation was developed by adding the relative observed values to the animal reference group values. By deriving the prediction equations for the protein, fat or energy content in the animal body, in function of the EBW logarithm, the prediction equations for the net requirements of protein, energy or fat content for gain of 1 kg of EBW were obtained, as follows:

$$Y' = b.\,10^{a}.\,X^{b-1},$$

where: Y'= net requirement of protein or energy and fat content in the gain; and a and b = intercept and regression coefficient, respectively, of the prediction equations of fat, protein or energy body content, and X = EBW (kg).

Metabolizable protein for maintenance (MPm) and gain (MPg) requirements and crude protein requirements were obtained by using the National Research Council (NRC, 1996) equations.

The results were statistically interpreted by analysis of variance and regression, using the System for Genetic Analysis and Statistics - SAEG (UFV, 2000). The regression equations for the evaluated parameters for each level of supplement offer were compared to test the identity models, according to methodology recommended by Regazzi (1996).

Results and Discussion

The estimate obtained for EBW from the animals BW was: EBW * BW = 0.8360. This value is lower than that recommended by the NRC (2000), of 0.8910 and 0.8975 and 0.8956 reported, respectively, by Silva et al. (2002a) and Paulino et al. (2004ab), obtained from Nellore animals in feedlot confinement. Empty body weight to BW ratio of 0.8360, observed in this work, was close to 0.8575, reported by Zervoudakis et al. (2002), working with Holstein × Zebu crossbred steers, and 0.8506, observed by Fregadolli (2005) working with Nellore animals, both experiments carried out on pasture. This difference between animals raised in feedlot and pasture may be justified by the influence of the level of supplement offer and particle size ingested in EBW, whereas animals with higher forage intake showed greater content retention in TGI, therefore the EBW:BW ratio was lower (Owens et al., 1995). The following relationship was obtained for conversion of the requirements for gain in EBW (EBWgain) in requirements for body weight gain (BWgain): EBWgain = 0.9702 × BWgain. This value was close to that recommended by the NRC (2000), which uses the ratio 0.9560. Thus, in the conditions of this work, to achieve the requirements for net gain of 1 kg BW, the requirements for gain of 1 kg of EBW must be multiplied by factor 0.97. The identity test between the models, applied to the regression equations of the logarithm for the animal body fat, protein or energy content, according to the EBW logarithm for the levels of supplementation offer, showed no difference among them. Thus, the regression equations were used considering the data all together (Table 3).

The body content of protein, fat and energy increased with increase in animal BW from 300 to 450 kg. The concentrations of fat (g/kg EBW), and energy (Mcal/kg EBW), increased, while protein (g/ kg EBW), decreased with the increase in BW (Table 4).

These results are in agreement with several reports in the literature (Silva, 2002ab, Paulino et al., 2004ab; Moraes, 2006). This behavior reflects the slowdown in muscle tissue growth in preference to the more rapid development of adipose tissue, due to the increase in EBW, since it gives further impulse for growth at older ages (Berg & Butterfield, 1979). To convert EBW gain requirements to BW gain requirements, the first is multiplied by the factor 0.97, obtained in this study (Table 5).

There were increases in fat content and energy requirements in empty body weight gain (EBWG) of 103.9 and 44.0%, respectively, for the animals from 300 kg to 450 kg BW. The results are consistent with those observed for animals reared on pasture (Zervoudakis et al., 2002; Fregadolli, 2005) and for animals reared in feedlot confinement (Silva, 2002a; Paulino et al., 2004a, Freitas et al., 2006). According to Berg & Butterfield (1976) as the weight increases, the concentration of fat in the body increases,

Table 3 - Parameters of the logarithm regression equations for the fat (kg), energy (Mcal) and protein (kg) content in the empty body, according to the empty body weight (kg) logarithm of Nellore steers for the different levels of supplement offer (%), and all together

Level of supplement offer (%)	Parameter		r^2
	Intercept (a)	Coeficient (b)	
	Fat		
0.0 (control)	-4.8314	2.5352	0.79
0.3	-6.1721	3.0739	0.88
0.6	-6.3536	3.1455	0.94
0.9	-5.7599	2.9084	0.89
All together	-5.3576	2.7546	0.79
	Energy		
0.0 (control)	-1.6950	1.8033	0.88
0.3	-2.3249	2.0561	0.93
0.6	-2.5077	2.1291	0.96
0.9	-2.1464	1.9849	0.91
All together	-1.9686	1.9017	0.86
	Protein		
0	-0.3053	0.8450	0.97
0.3	-0.1037	0.7630	0.95
0.6	-0.2079	0.8058	0.95
0.9	-0.2329	0.8160	0.96
All together	-0.2743	0.8316	0.92

with a consequent increase in energy requirements, because there is an increase in energy value of the gain with the increase in animal BW.

Silva et al. (2002b), compiled some studies on the nutritional requirements of Zebu animals and reported for an animal of 400 kg BW, values of body fat content and net energy requirements for gain of 331.86 g/kg EBWG and 3.92 Mcal/kg EBWG, respectively. These values are very close to the 320.75 g/kg EBWG and 3.84 Mcal/kg EBWG obtained in this experiment for an animal of the same weight.

As expected, the requirements for protein in EBWG decreased as the BW of the animals increased, obviously due to the increased concentration of fat in the gain at the expense of the protein. This was because the fat developed more intensively, with concomitant slowing of muscle growth with the increase in the BW of the animals. The net protein requirements, observed in an animal of 400 kg, of 166.37 g/kg EBWG of protein were 17.73% higher than those determined by Moraes (2006) for Nellore cattle on pasture, with the same BW. Silva et al. (2002a), worked with intact Nellore animals in feedlot, reported values ranging from 177.60 to 172.15 g/kg EBWG for 300 to 450 kg BW, respectively, higher than the values obtained in this experiment.

Table 4 - Estimate of animal body contents of protein, fat and energy according to body weight (BW) and empty body weight (EBW)

BW (kg)	Protein		Fat		Energy	
	kg	g/kg EBW	kg	g/kg EBW	(Mcal)	(Mcal/kg EBW)
300	52.31	209.96	17.53	70.35	388.01	1.56
350	59.47	204.58	26.80	92.21	520.19	1.79
400	66.45	200.03	38.72	116.5	670.57	2.02
450	73.29	196.10	53.56	143.3	838.92	2.24

EBW = BW*0.8360.

Table 5 - Net requirements for protein (g/kg EBW gain) and energy (Mcal kg EBW gain) and fat content (g/ kg EBW gain), according to body weight (BW)

BW (kg)	Requirement (g/kg EBW gain)		Fat content
	Protein (g/kg EBW gain)	Energy (Mcal/kg EBW gain)	
300	174.62	2.96	193.62
350	170.15	3.40	253.76
400	166.37	3.84	320.75
450	163.10	4.27	394.39

EBW = BWV*0.8360.

The following equation was obtained from the data of this study to estimate the retained protein (RP) (g/day), in function of fasting BW gain by (FBWG) (kg/day), and retained energy (RE) (Mcal/day): RP = 28.9199 + 85.7301 * FBWG + 8.0669 * RE (r^2 = 0.58).

The NRC (1996) recommended the equation RP = FBWG (268 - (29.4 (RE/FBWG) to estimate the net protein requirements for gain (RP). By using the equation obtained in the present experiment, for an animal of 400 kg, gaining 1 kg BW per day, and replacing the RE value for the animal, in function of the equation described later in this study, 4.40 Mcal/day, the daily net protein retention obtained was of 150.14 g. Substituting these data is the NRC equation (1996), the daily net protein retention obtained was of 138.64 g, a value 8.3% lower then that observed in the present study. This may be due to the difference between a breed used by the committee as compared to the present experiment.

Metabolizable protein requirements (MP), were calculated according to the NRC (1996), using values referring to net protein requirements for weight gain, but based on all the data (Table 6).

Véras et al. (2008), using Nellore cattle (castrated, intact and females), obtained the value of 4.03 g/kg $BW^{0.75}$ for the MPm, regardless of gender. This value was very close to the value of 3.8 g/kg $BW^{0.75}$adopted by the NRC (2000) and 4.13 g/kg $BW^{0.75}$ estimated by Valadares et al. (1997). Thus, the value of 4.00 g/kg $BW^{0.75}$ was adopted to achieve the MPm for Nellore, as recommended by Valadares Filho et al. (2006).

As can be seen, the MPm requirements increased with the increase in BW, which was expected, although the MPm were in function of BW. The following equation was used (efficiency of 49.2%) to convert MP for gain for animals over 300 kg EBW and for animals under 300 kg EBW: Efficiency = (83.4 - (0114 × EBW)), according to Ainslie et al. (1993). For an animal of 450 kg BW, with 1 kg BWG, the requirement of total MP, according to data of the present experiment, was 692.64 g, 13% higher than recommended by Valadares Filho et al. (2006) for castrated zebu cattle showing the same weight and same rate of gain.

Adopting the protocol described by the NRC (2000) and an average intake of 15.55 g TDN intake/kg EBW, observed in this experiment, the MP requirements were converted into rumen degradable protein (RDP), rumen undegradable protein (RUP) and crude protein (CP) (Table 7).

The requirements for rumen undigestible protein (RUP) decreased with the increase in BW. This fact has been reported by several authors (Silva et al. 2002a; Paulino et al. 2004b; Paulino, 2006; Moraes, 2006), indicating greater involvement of the RDP in the supply of total crude protein (CP) requirements with the increase in BW, and that higher levels of non-protein nitrogen can be used in the diet of finishing animals.

The regression equation obtained in this experiment to describe the relationship between the daily RE (Mcal/day), and daily EBWG (DEBWG) (kg/day), for a given EBW, was:

$$ER = 0.05764 \times EBW^{0.75} \times DEBWG^{0.8328} \ (r^2 = 0.49)$$

This differs from the equation recommended by the NRC (2000) for a medium-sized steer, which is as follows: ER (Mcal/day) = 0.0635 * $EBW^{0.75}$ * $DEBWG^{1.097}$. Using the national data from different studies, Valadares Filho et al. (2006) obtained ER = 0.0608 * $EBW^{0.75}$ * $DEBWG^{1.0996}$ for castrated Zebu animals.

From the above equation, ER of an animal with 1.0 kg DEBWG and 400 kg of BW iwas equal to 4.40 Mcal/day. This value was lower than those obtained by the equations of Valadares Filho et al. (2006) and NRC (2000), which were 4.60 and 4.81 Mcal/day, respectively. The retained energy values observed in this study were lower (9%) than those obtained by the NRC (2000) equation, and this could be explained, according to Silva (2002a), by the smaller amounts of marbling fat and total fat reported for zebu cattle, compared to the majority of *Bos taurus*, especially when reared on pasture.

The net energy requirement for gain of 0.5 kg BW in an animal of 400 kg was 2.26 Mcal/day, close to 2.18 Mcal/day reported by Moraes (2006) in a study of Nellore animals on pasture (Table 8).

Total CP requirement for an animal of 450 kg BW and gain of 0.5 kg was 727.57, below 767.44 and 775.28 g/day, reported by Valadares Filho et al. (2006) and Moraes (2006), respectively. Paulino (2006), worked with castrated Nellore animals and reported a total dietary requirement of 4.12 kg TDN/day for an animal of 400 kg BW and 0.5 kg gain, close to the value obtained in the present experiment of 4.08 kg/day. It was observed that the dietary TDN and CP requirements increased as the BW of the animals increased, which, according to Paulino et al. (2004b), was only possible

Table 6 - Requirements of metabolizable protein for maintenance (MPm) and for gain (MPg) for 1 kg EBW(g/kg EBW gain), according to body weight (BW)

BW (kg)	MPm[1]	MPg[2]
300	288.34	253.87
350	323.68	285.37
400	357.77	296.02
450	390.81	301.83

EBW = BW * 0.8360.
[1] 4.0 $g/w^{0.75}$ (Valadares Filho et al., 2006).
[2] Net requirement/0.492 for EBW > 300 kg; Net requirement /(83.4 - (0.114 × EBW)) for EBW ≤ 300 kg (NRC, 1996).

Table 7 - Intakes of rumen degradable protein (RDP), rumen undegradable protein (RUP), crude protein (CP) and total digestible nutrients (TDN) for maintenance and 1 kg BW gain

BW (kg)	RDP (g/day)	RUP (g/day)	CP (g/day)	TDN (kg/day)
300	529.1	287.4	816.6	4.20
350	594.0	263.8	857.8	4.72
400	656.5	242.3	898.8	5.21
450	717.2	222.3	939.5	5.69

EBW = BW * 0.8360.

Table 8 - Nutritional requirements for energy and protein, according to body weight (BW) and average daily gain (ADG)

Item		Body weight (kg)			
		300	350	400	450
Maintenance requirement					
NEm[1]	Mcal/d	4.61	5.18	5.72	6.25
MPm[2]	g/d	288.34	323.68	357.77	390.81
Gain requirement		NEg, Mcal/d[3]			
ADG	0.3 kg/d	1.19	1.34	1.48	1.61
	0.5 kg/d	1.82	2.04	2.26	2.47
	0.7 kg/d	2.41	2.71	2.99	3.27
		MPg, g/d[4,5]			
ADG	0.3 kg/d	116.00	129.85	134.17	136.30
	0.5 kg/d	156.01	175.05	181.27	184.53
	0.7 kg/d	195.43	219.53	227.56	231.88
Total requirement		ME, Mcal/d[6]			
ADG	0.3 kg/d	10.26	11.52	12.73	13.91
	0.5 kg/d	11.88	13.33	14.74	16.10
	0.7 kg/d	13.39	15.03	16.61	18.15
		TDN, kg/d[7]			
ADG	0.3 kg/d	2.84	3.19	3.52	3.85
	0.5 kg/d	3.29	3.69	4.08	4.45
	0.7 kg/d	3.70	4.16	4.59	5.02
		CP, g/d[8]			
ADG	0.3 kg/d	542.01	607.97	660.31	708.47
	0.5 kg/d	598.78	672.06	727.57	777.93
	0.7 kg/d	654.36	734.73	793.26	845.65

Nem = net energy for maintenance; MPm = metabolizable protein for maintenance; Neg = net energy for gain; MPg = metabolizable protein for gain; ME = metabolizable energy; TDN = total digestible nutrients; CP = crude protein. According to: [1] NEm = 69.33 kcal/$EBW^{0.75}$ (Moraes, 2006), [2] MPm = 4.0 g/$kg^{0.75}$ (Valadares Filho et al., 2006), [3] NEg = 0,05764*$EBW^{0.75}$*$GDEBW^{0.8328}$, [4] Retained protein (RP) = 166.88 – 47.52*ADG – 0.9417*NEg, [5] MP = net requirements/0.492 for EBW >300 kg; or net requirements/[83.4 - (0.114 × EBW)]*100, for EBW $\leq$ 300 kg (NRC, 2000), [6] km = 0.64 and kf = 0,39 (Valadares Filho et al., 2006), [7] NDT = ME/0.82/4.409 (NRC, 2000), [8] CP = MP total/0.672 (NRC, 2000), Net requirements for EBW gain were transformed to BW gain using the factor 0.9702, observed in the present study: EBW= BW*0.8360.

due to the fact that maintenance requirements were included in the calculation for total requirements, although maintenance requirements and energy and protein increased as the W of the animals increased The same occurred with weight gain requirements, that is, as the BW increased, the net energy requirements also increased, due to the fact that fat deposition was more pronounced.

Conclusions

The net protein requirement of Nellore steers, reared on pasture, could be obtained by the equation: RP (g/day) = 28.9199 + 85.7301 FBWG + 8.0669 ER.

The net energy requirements for weight gain of Nellore steers, reared on pasture (Mcal/kg), could be obtained by the equation: $RE = 0.05764 \times EBW^{0.75} \times DEBWG^{0.8328}$.

Literature Cited

AINSLIE, S.J.; FOX, D.G.; PERRY, T.C. et al. Predicting amino acid adequacy of diets fed to Holstein steers. **Journal of Animal Science**, v.71, p.1312- 1319, 1993.

AGRICULTURAL RESEARCH COUNCIL - ARC. **The nutrient requirements of ruminants livestock**. London: Commonwealth Agricultural Bureaux, 1980. 351p.

BERG, R.T., BUTTERFIELD, R.M. **Nuevos conceptos sobre desarrollo de ganado vacuno**. El crecimiento del ganado vacuno y la producción de carne de vacuno. Zaragoza, 1979. p.16-29.

BERG, R.T.; BUTTERFIELD, R.M. **New concepts of cattle growth**. New York: Sydney University, 1976. 240p.

BURNS, J.C.; POND, K.R.; FISHER, D.S. Measurament of forage intake. In: FAHEY JR., G.C. (Ed.) **Forage quality, evaluation and utilization**. Madison: America Society of Agronomy, 1994. p.494-531.

FONTES, C.A.A. Composição corporal, exigências líquidas de nutrientes para ganho de peso e desempenho produtivo de animais zebuínos e mestiços europeu-zebu. Resultados experimentais. In: SIMPÓSIO INTERNACIONAL SOBRE EXIGÊNCIAS NUTRICIONAIS DE RUMINANTES, 1., 1995, Viçosa, MG. **Anais...** Viçosa, MG: Universidade Federal de Viçosa, 1995. p.419-455.

FREGADOLLI, F.L. **Composição corporal e exigências nutricionais de novilhos de três grupos genéticos em pastejo**. 2005. 85f. Tese (Doutorado em Zootecnia) - Universidade Estadual Paulista, Faculdade de Ciências Agrárias e Veterinárias, Jaboticabal, 2005.

FREITAS, J.A.; QUEIROZ, A.C.; DUTRA, A.R. et al. Composição corporal e exigências de energia de mantença em bovinos Nelore, puros e mestiços, em confinamento. **Revista Brasileira de Zootecnia**, v.35, n.3, p.878-885, 2006.

GEAY, Y. Energy and protein utilization in growing cattle. **Journal of Animal Science**, v.58, n.3, p.766-778, 1984.

HANKINS, O.G.; HOWE, P.E. **Estimation of the composition of beef carcasses and cuts**. [T.B.]: United Sates Department of Agriculture, 1946. p.1-19. (Technical Bulleti, 926).

LOFGREEN, G.P.; GARRET, W.N.A. System for expressing net energy requirements and feed values for growing and finishing beef cattle. **Journal of Animal Science**, v.27, n.3, p.793-806, 1968.

MORAES, E.H.B.K. **Desempenho e exigências de energia, proteína e minerais de bovinos de corte em pastejo, submetidos a diferentes estratégias de suplementação**. 2006. 151f. Tese (Doutorado em Zootecnia) – Universidade Federal de Viçosa, Viçosa, MG, 2006.

NATIONAL RESEARCH COUNCIL - NRC. **Nutrient requirements of beef cattle**. 7.rev.ed. Washington, DC.: National Academy Press, 2000. 242p.

NATIONAL RESEARCH COUNCIL - NRC. **Nutrients requirements of beef cattle**. 7.ed. Washington, D.C.: National Academy Press, 1996. 242p.

OWENS, F.N.; GILL, D.R.; SECRIST, D.S. et al. Review of some aspects of growth and development of feedlot cattle. **Journal of Animal Science**, v.73, p.3152-3172, 1995.

PAULINO, P.V.R. **Desempenho, composição corporal e exigências nutricionais de bovinos Nelore de diferentes classes sexuais**. 2006. 167f. Tese (Doutorado em Zootecnia) – Universidade Federal de Viçosa, Viçosa, MG, 2006.

PAULINO, P.V.R.; COSTA, M.A.L.; VALADARES FILHO, S.C. et al. Exigências nutricionais de zebuínos: energia. **Revista Brasileira de Zootecnia**, v.33, n.3, p.781-791, 2004a.

PAULINO, P.V.R.; COSTA, M.A.; VALADARES FILHO, S.C. et al. Exigências nutricionais de zebuínos: Proteína. **Revista Brasileira de Zootecnia**, v.33, n.3, p.759-769, 2004b.

REGAZZI, J.A. Teste para verificar a identidade de modelos de regressão. **Pesquisa Agropecuária Brasileira**, v.31, n.1, p.1-17, 1996.

SILVA, D.J.; QUEIROZ, A.C. **Análise de alimentos** (métodos químicos e biológicos). Viçosa, MG: Universidade Federal de Viçosa, 2002. 235p.

SILVA, F.F.; VALADARES FILHO, S.C.; ÍTAVO, L.C.V. et al. Composição corporal e requisitos energéticos e protéicos de bovinos nelore, não-castrados, alimentados com rações contendo diferentes níveis de concentrado e proteína. **Revista Brasileira de Zootecnia**, v.31, n.1, p.503-513, 2002a.

SILVA, F.F.; VALADARES FILHO, S.C.; ÍTAVO, L.C.V. et al. Exigências líquidas e dietéticas de energia, proteína e macroelementos minerais de bovinos de corte no Brasil. **Revista Brasileira de Zootecnia**, v.31, n.2, p.776-792, 2002b.

SNIFFEN, C.J.; O'CONNOR, J.D.; Van SOEST, P.J. et al. A net carbohydrate and protein system for evaluating cattle diets: II-Carbohydrate and protein availability. **Journal of Dairy Science**, v.70, p.3562-3577, 1992.

UNIVERSIDADE FEDERAL DE VIÇOSA - UFV. **Sistema de Análises Estatísticas e Genéticas - SAEG**. Versão 8.0. Viçosa, MG, 2000. 142p.

VALADARES FILHO, S.C.; PAULINO, P.V.R.; DETMANN, E. et al. Exigências nutricionais de zebuínos no Brasil I e II. In: VALADARES FILHO, S.C.; PAULINO, P.V.R; MAGALHÃES, K.A. (Eds.) **Exigências nutricionais de zebuínos e tabelas de composição de alimentos BR-Corte**. 1.ed. Viçosa, MG: Suprema, 2006. 142p.

VALADARES, R.F.D.; GONÇALVES, L.C.; RODRIGUEZ, N.M. et al. Níveis de proteína em dietas de bovinos. 1. Consumo e digestibilidades aparentes totais e parciais. **Revista Brasileira de Zootecnia**, v.26, n.6, p.1252-1258, 1997.

VANDERWERT, W.; BERGER, L.L.; McKEITH, F.K. et al. Influence of zeranol implants on growth, behaviour and carcass traits in Angus and Limousin bulls and steers. **Journal of Animal Science**, v.61, p.310-319, 1985.

VÉRAS, R.M.L.; VALADARES FILHO, S.C.; AZEVEDO, J.A.G. et al. Níveis de concentrado na dieta de bovinos Nelore de três condições sexuais: consumo, digestibilidades total e parcial, produção microbiana e parâmetros ruminais. **Revista Brasileira de Zootecnia**, v.37, n.5, p.951-960, 2008.

ZERVOUDAKIS, J.T.; PAULINO, M.F.; DETMANN, E. et al. Conteúdo corporal e exigências líquidas de proteína e energia de novilhos suplementados no período das águas. **Revista Brasileira de Zootecnia**, v.31, n.1, p.530-537, 2002.