California net energy system for *Bos taurus indicus*

Mario Luiz Chizzotti,[*,1] **Sebastião de Campos Valadares Filho,**[*] **Pedro Del Bianco Benedeti,**[†] **and Flávia Adriane de Sales Silva**[*]

*Department of Animal Science, Universidade Federal de Viçosa, Viçosa, Minas Gerais 36570-900, Brazil; †Department of Animal Science, Universidade do Estado de Santa Catarina, Chapecó, Santa Catarina 89815-630, Brazil

ABSTRACT: The California net energy system (CNES) was the reference for the development of most energy requirement systems worldwide, such as Nutrient Requirements of Beef Cattle (NASEM, Nutrient requirements of beef cattle, 8th Revised ed, 2016) and Brazilian Nutrient Requirements of Zebu and Crossbred Cattle (Valadares Filho, S. C., L. F. C. Silva, M. P. Gionbelli, P. P. Rotta, M. I. Marcondes, M. L. Chizzotti, and L. F. Prados, BR-CORTE: nutrient requirements of zebu and crossbred cattle, 3rd ed, 2016). This review aimed to compare methods used by NASEM and BR-CORTE to estimate the energy requirements for beef cattle. The net energy requirements for maintenance (NE*m*) of BR-CORTE is based on empty body weight (EBW), whereas NASEM uses shrunk body weight (SBW), but the *Bos taurus indicus* presents 10% to 8% lower NE*m* than *Bos taurus taurus*. We have compared animals with different EBW and SBW but with same equivalent empty body weight/standard reference weight ratio (0.75), as both systems have suggested different mature weights. Both systems predicted similar net energy requirements for gain (NE*g*) for animals with 1.8 kg of daily gain. However, estimated empty body gain was lower for NASEM estimations when the same metabolizable energy for gain is available. For pregnancy and lactation of beef cows, the NE*m* and net energy requirements for pregnancy (NE*p*) of a Zebu cow estimated by BR-CORTE were lower than the values estimated by NASEM. Furthermore, the magnitude of differences between these systems regarding NE*p* increased as pregnancy days increase. The NASEM and BR-CORTE systems have presented similar values for energy requirement for lactation (0.72 and 0.75 Mcal/kg milk, respectively).

Key words: beef cattle, BR-CORTE, Nellore, requirements

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INTRODUCTION

The United States and Brazil are ranked first and second largest beef producers in the world, respectively (USDA, 2017). However, despite have accounting together for about 35% of world's beef production, both countries have distinct beef cattle production systems. In the United States predominates a specialized system using most *Bos taurus taurus* steers finished in feedlots on high-energy diets aiming to increase beef marbling. On the other hand, Brazilian beef cattle systems are based on tropical grasses pastures with only 9% of beef cattle finished in feedlots in 2017 (ANUALPEC, 2018). Furthermore, *Bos taurus indicus* bulls are predominant in Brazilian system, resulting in lower

[1]Corresponding author: mario.chizzotti@ufv.br
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percentage of marbling of beef and leaner carcasses, and usually no price difference or marbling grades are used by this country's industry, making the use of Zebu bulls more profitable.

The accurate estimation of energy requirements for growing and finishing cattle is a major key point for diets formulation. The California net energy system (CNES) was first developed by Lofgreen and Garrett (1968), which uses data from several studies (Atwater and Bryant, 1900; Armsby, 1917; Kleiber, 1961; Blaxter, 1962, 1969; Brody, 1945; Blaxter et al., 1966) that have evaluated the most varied aspects of energy usage by cattle (mainly *Bos taurus taurus*) as basis for its proposed definitions. The CNES in turn established the basis for energy requirement recommendations of the subsequent editions of the North American System (NRC, 1984, 1996, 2000; NASEM, 2016). However, due to differences between carcasses (especially marbling) produced in the United States and Brazil, the CNES may not correctly estimates the energy requirements for Zebu bulls under tropical condition. Thus, a Brazilian system was developed and has been regularly updated. We present the Brazilian system entitled Nutrient Requirements of Zebu and Crossbred Cattle, BR-CORTE, (Valadares Filho et al., 2016) and contrast with CNES (Lofgreen and Garrett, 1968) and NASEM (2016) for requirements predictions for *Bos taurus indicus* and their crosses with beef and dairy *Bos taurus taurus* breeds.

NUTRIENT REQUIREMENTS OF ZEBU AND CROSSBRED CATTLE—BR-CORTE

Brazilian studies on evaluation of cattle nutritional requirements have started in the 1980s, and the first attempt to systematize these requirements data was made in 1995, at the International Symposium on Nutritional Requirements of Ruminants, in Viçosa, Brazil. The first edition of BR-CORTE system (Valadares Filho et al., 2006) was published in June 2006 and has used individual data from about 180 Zebu bulls (from nine studies) on feedlot. Since then, the number of studies and data has increased and the second version of BR-CORTE, published in 2010, included information of crossbred animals as well as the new chapters on cows and calves requirements. The last edition of BR-CORTE was published in October 2016 and had included four new chapters, using a new and updated database collected from different Brazilian universities (Valadares Filho et al., 2016), integrating the National Institute of Animal Science (INCT-CA). The updated BR-CORTE gathered individual data from 1,369 animals used in 38 studies, regarding nutritional requirements for Zebu, dairy and beef crossbred cattle, fed on pasture or feedlot under Brazilian beef cattle production conditions.

The BR-CORTE's methodology on the estimation of energy requirements for growing and finishing cattle was based on the CNES presented by Lofgreen and Garrett (1968). To use this system, the first step is determining animals' body composition, and from comparative slaughter of an initial group, estimating the initial body energy content, to further estimate the net energy retained in the body.

Methods used to predict body composition can be classified as direct or indirect. Direct methods are expensive, very labor-intensive, and slow, as separation and dissection of all body components are necessary for the further quantification of physical and chemical components. On the other hand, body composition might be predicted by indirect methods without the necessity of complete carcass dissection. The BR-CORTE system uses a database from studies using mostly direct body composition (Garrett et al., 1959) and some indirect methods based on rib sections composition (Marcondes et al., 2010, 2012).

USE OF THE 9TH-10TH-11TH RIB CUT FOR PREDICTION OF BODY COMPOSITION

Hankins and Howe (1946) have developed equations for prediction of carcass physical and chemical composition from a rib section between the 9th and 11th ribs. These equations were developed from data obtained from steers and heifers, and three equations (one for each gender and one wide-ranging) were proposed. The accuracy of original equations from Hankins and Howe (1946) was not satisfactory for Zebu or crossbred bulls, and reparametrized equations were developed by Marcondes et al. (2010, 2012). The inclusion of new variables into models to predict body and carcass composition, such as effects of gender and genotype, as well other body components such as visceral fat, have improved the estimates from the 9th to 11th rib section for Zebu cattle and are currently adopted as the indirect method used in BR-CORTE database.

ENERGY REQUIREMENTS

For maintenance requirements, the nonlinear relationship of heat production (HP) and metabolizable energy intake (MEI) is used to estimate the fasting HP, expressed as energy per unit of metabolic body weight.

The BR-CORTE's dataset used to obtain energy requirements is composed of 1,369 animals from 38 studies carried out under Brazilian conditions. These animals were distributed in three genetic groups (54% Nellore, 25% crossbred beef, and 25% crossbred dairy), two feeding system groups (91% feedlot and 9% pasture), and three gender groups (62% bulls, 26% steers, and 12% heifers). The net energy requirements for maintenance (NE*m*) were estimated using an exponential nonlinear regression of HP as a function of MEI (Ferrell and Jenkins, 1998), according to the general model: $HP = \beta_1 \times e^{(\beta 2 \times MEI)}$.

Fixed effects of gender, genetic group, and feeding system were tested in mixed models considering the random effects of studies. The intercept β_1, representing NE*m*, was not affected ($P > 0.05$) by gender, genetic group, or feeding system, which indicates no differences in NE*m* (0.0749 of Mcal/EBW$^{0.75}$/d). Therefore, BR-CORTE proposed a general value of 75 kcal/EBW$^{0.75}$/d for NE*m*. Nonetheless, the exponent β_2 was greater for crossbred dairy group followed by crossbred beef and Nellore, respectively ($P < 0.01$). These results indicate that genetic group influences the efficiency of use of metabolizable energy for maintenance (K*m*). Therefore, three equations were proposed to estimate metabolizable energy requirements for maintenance (in Mcal/EBW$^{0.75}$/d) for Zebu ($HP = 0.0749 \times e^{3.8684 \times MEI}$), beef crossbred ($HP = 0.0749 \times e^{4.0612 \times MEI}$), and dairy crossbred ($HP = 0.0749 \times e^{4.1487 \times MEI}$; Figure 1).

Conceptually, metabolizable energy requirements for maintenance (ME*m*) can be defined as MEI to achieve null energy balance in body (RE = 0), or MEI = HP (Lofgreen and Garrett, 1968). The ME*m* can be estimated by iterative process from the aforementioned equations, and our data indicate an ME*m* of 118, 124, and 125 kcal/EBW$^{0.75}$/d for Zebu, beef crossbred, and dairy crossbred, respectively, indicating a difference of about 5.2% on ME*m* for Zebu in comparison with their crosses.

The NE*m* estimated by CNES and adopted by NASEM (2016) was of 77 kcal/SBW$^{0.75}$/d for a *Bos taurus taurus* steer. The CNES and NASEM (2016) use shrunk body weight (SBW) whereas BR-CORTE uses empty body weight (EBW) to estimate the NE*m*, which can generate confusion during direct comparison of both systems or genotypes. Therefore, in CNES and NASEM (2016), the NE*m* of a 450 kg of body weight steer of *Bos taurus* genotype will be calculated from the SBW of 432 kg (SBW = BW × 0.96), resulting in an NE*m* of 7.30 Mcal/d ($0.077 \times 432^{0.75}$). In contrast, a *Bos taurus indicus* steer of 450 kg in BR-CORTE system will be estimated from 441 kg of SBW and 398 kg of EBW, resulting in an NE*m* of 6.69 Mcal/d ($0.075 \times 398^{0.75}$), which is about 8% smaller than that obtained from CNES (Figure 2). Therefore, there might be a difference between *Bos taurus indicus* and *Bos taurus taurus* for NE*m*.

Different from NASEM (2016), the BR-CORTE system does not adjust NE*m* for gender condition, as there was no difference between then on our dataset. The NASEM recommended a 15% increase in NE*m* for bulls. Furthermore, the NASEM also proposed a reduction of 10% in NE*m* requirements of Zebu cattle, except for Nellore. The BR-CORTE does not propose any corrections for gender or genetic group for NE*m*.

The estimation of EBW is also different between systems. In NASEM (2016) the EBW is considered as a fixed fraction 0.891 of SBW. Nonetheless, our data indicate a nonlinear relationship between EBW and SBW, evidenced by the increased carcass yield observed for heavier animals. Therefore, the BR-CORTE has dedicated an

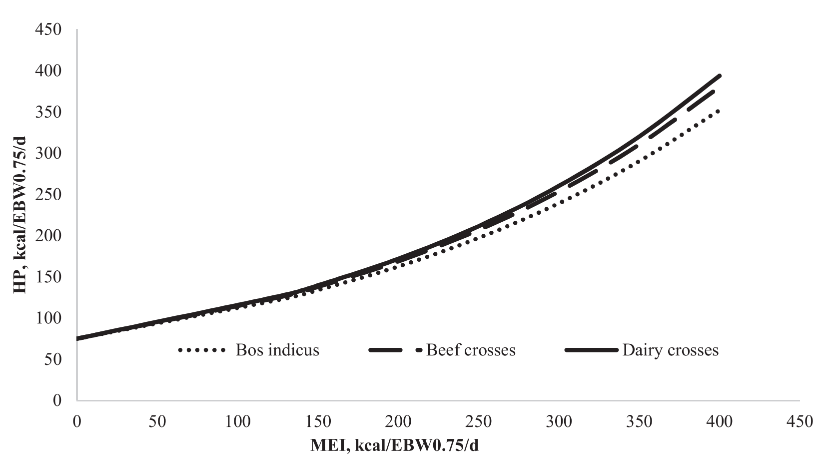

Figure 1. Representation of the relationship between heat production (HP) and metabolizable energy intake (MEI) by using BR-CORTE equations.

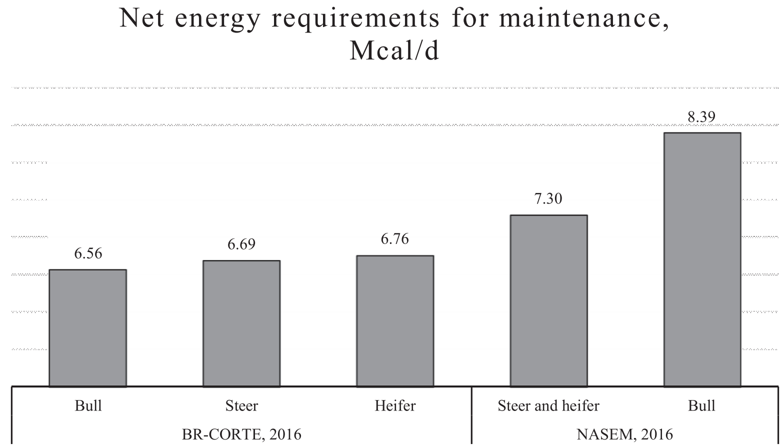

Figure 2. Net energy requirements for maintenance calculated for Nellore animals with different gender and averaging 450 kg of BW by using NASEM and BR-CORTE systems.

entire chapter just to estimate EBW, as its prediction was affected by gender and genotype and also by SBW (Table 1).

Gomes et al. (2016) evaluated the nutrient requirements of Angus purebred and Nellore purebred bulls under tropical conditions and reported that Angus bulls had 28% greater NE*m*, 29% greater intake, and 146% greater respiration rate than Nellore bulls, indicating that under heat stress of tropics, the difference between purebred *Bos taurus taurus* and *Bos taurus indicus* might be even higher than that suggested by NASEM (2016).

Energy Requirements for Gain

The understanding of the composition of gain is critical to estimate energy requirements and is related to the stage of maturity of the animal (Marcondes et al., 2015). The NRC (2000) suggests the use of equivalent empty body weight (EQEBW) to correct energy requirements for gain of animals with different frame size (or BW at maturity), in order to generate an equivalent value among all animals. The EQEBW allows the comparison of animals with different genetic groups and/or gender at different finishing grades. The EQEBW can be calculated from mature EBW and a standard reference weight (SRW), adopting the following model: EQEBW = (EBW/mature − EBW) × SRW. The NASEM (2016) uses four different SRW, according to empty body fat (EBF) content: 478 kg for animals with small marbling (28% EBF), 462 kg for animals with slight marbling (27% EBF), 435 for animals with traces of marbling (25% EBF), and 400 for animals devoid of marbling (22% EBF). For the BR-CORTE, the mature EBW was suggested for each gender and genotype, from the relationship of body fat and EBW. It was considered a body composition of 25% EBF as the weight at maturity for Zebu cattle, because of a low degree of beef marbling. Thus, the BR-CORTE suggests the following mature EBWs: for Zebu = 517, 433, and 402 kg for bulls, steers, and heifers, respectively; for beef crosses = 560, 482, and 417 kg for bulls, steers, and heifers, respectively; for dairy crosses = 616, 532, and 493 kg for bulls, steers, and heifers, respectively. The SRW of BR-CORTE is of 517 kg, and the estimate of EQEBW based on different mature BWs, account for most of the variation of gender and genotype on net energy requirement for gain (NE*g*).

The BR-CORTE estimates NE*g* based on net energy retained in the body as a function of EQEBW and empty body gain (EBG) with a similar equation ($NEg = 0.061 \times EQEBW^{0.75} \times EBG^{1.035}$) to the one adopted by NASEM ($0.0635 \times EQEBW^{0.75} \times EBG^{1.097}$). It is important to depict that there is a small difference in the coefficients of equation to predict NE*g* between systems (0.061 vs. 0.0635, and 1.035 vs. 1.097), which will result in reduced energy content in the gain for Zebu cattle (BR-CORTE) than that of *Bos taurus* cattle (NASEM), consistent with the lower marbling of beef.

For metabolizable energy requirements for gain (ME*g*), an efficiency of the use of metabolizable energy for gain (K*g*) needs to be calculated. The efficiency of body energy retention depends on the proportions of energy retained as protein and as fat, because energy deposition as fat is more efficient than that as protein (Owens et al., 1995). The BR-CORTE (2016) adopts a nonlinear equation to predict K*g* from the energy content in the gain: $Kg = 0.327/(0.539 + [1.14 \times (NEg/EBG)^{-1.137}])$. On the other hand, the NASEM (2016) uses the diet ME concentration to estimates K*g*, leading to some difference on energy required for gain.

Table 1. Equations of BR-CORTE (2016) and NASEM (2016) systems used to estimate energy requirements in Table 2

Item	BR-CORTE (2016)	NASEM (2016)
DMI, kg	Zebu = $-1.7824 + 0.07765 \times BW^{0.75} + 4.0415 \times ADG - 0.8973 \times ADG^2$; Crossbred beef = $-0.6273 + 0.06453 \times BW^{0.75} + 3.871 \times ADG - 0.614 \times ADG^2$	If $Km \geq 1$, $(1.2425 + 1.9218 \times Km - 0.7259 \times Km^2) \times SBW/100$; If $Km < 1$, $(1.2425 + 1.9218 \times 0.95 - 0.7259 \times 0.95 \times 0.95) \times SBW/100$
Diet ME, Mcal/kg	ME of diet D used in chapter 20's tables of NASEM	ME of diet D used in chapter 20's tables of NASEM
SRW, kg	SRW considering an animal with 25% of body fat	SRW considering an animal with 28% of empty body fat
SBW, kg	Zebu = $0.88 \times BW^{1.0175}$; Crossbred beef = $0.9664 \times BW^{1.0017}$	$0.96 \times BW$
Mature SBW, kg	—	Reference values used in chapter 20's tables
Mature EBW, kg	Zebu: bull = 517; steer = 433; heifer = 402; Crossbred beef: bull = 560; steer = 482; heifer = 417	Mature SBW × 0.891
EQSBW, kg	—	SBW × (SRW/mature SBW)
EBW, kg	Zebu: bull = $0.8126 \times SBW^{1.0134}$; steer = $0.6241 \times SBW^{1.0608}$; heifer = $0.611 \times SBW^{1.0667}$; Crossbred beef: bull = $0.7248 \times SBW^{1.0314}$; steer = $0.6586 \times SBW^{1.0499}$; heifer = $0.6314 \times SBW^{1.0602}$	0.891 × SBW
EQEBW, kg	EBW/mature EBW × SRW	0.891 × EQSBW
EQEBW/SRW	75%	75%
EBG, kg	$0.963 \times ADG^{1.0151}$	0.956 × ADG
NE*m*, Mcal/d	$0.075 \times EBW^{0.75}$	*Bos taurus taurus*: heifer and steers = $0.077 \times SBW^{0.75}$; bulls = 15% greater; Zebu = 10% lower
NE*g*, Mcal/d	$0.061 \times EQEBW^{0.75} \times EBG^{1.035}$	$0.0635 \times EQEBW^{0.75} \times EBG^{1.097}$
NE, Mcal/d	NE*m* + NE*g*	NE*m* + NE*g*
K*m*	Zebu = $0.513 + 0.173 \times Kg + 0.1 \times EBG$; Crossbred beef = $0.513 + 0.173 \times Kg + 0.073 \times EBG$	$(1.37 \times \text{Diet ME} - 0.138 \times \text{Diet ME}^2 + 0.0105 \times \text{Diet ME}^3 - 1.12)/\text{Diet ME}$
K*g*	$0.327/(0.539 + (1.14 \times (NEg/EBG)^{-1.137}))$	$(1.42 \times \text{Diet ME} - 0.174 \times \text{Diet ME}^2 + 0.0122 \times \text{Diet ME}^3 - 1.65)/\text{Diet ME}$
ME*m*, Mcal/d	NE*m*/K*m*	NE*m*/K*m*
ME*g*, Mcal/d	NE*g*/K*g*	NEg/K*g*
ME*t*, Mcal/d	ME*m* + ME*g*	ME*m* + ME*g*
DE, Mcal/d	(((ME/DMI) + 0.3032) 0.9455) × DMI	ME/0.82
TDN, kg	DE/4.4	DE/4.4

ADG = average daily gain; DMI = dry matter intake; ME = metabolizable energy; EQSBW = equivalent shrunk body weight; NE = net energy requirement; K*m* = efficiency of use of NE*m*; K*g* = efficiency of use of NE*g*; ME*t* = total metabolizable energy requirement; DE = digestible energy requirement; TDN = total digestible nutrients requirement.

BR-CORTE (2016) VS. NASEM (2016)

Growing and Finishing Cattle

Table 1 shows the equations used to estimate energy requirements presented in Table 2, which compares BR-CORTE (2016) and NASEM (2016) systems. Because both systems have suggested different mature weights, we decided to compare animals with different EBW and SBW but with same EQEBW/SRW ratio (0.75). Therefore, both systems presented similar NE*g* for animals with 1.8 kg of average daily gain, as proposed equations are similar too.

The BR-CORTE system uses 517 kg as SRW. On the other hand, the NASEM suggests an SRW of 478 kg, considering an animal with 28% of EBF. The mature SBW used for NASEM calculations were those described in chapter 20.

Differences in K*m* and K*g* calculations between both systems also should be highlighted. The NASEM equations use only diets ME, whereas BR-CORTE equations consider EBG, NE*g*, and K*g* variables. Generally, BR-CORTE K*m* and K*g* present greater values than those calculated using NASEM.

The EBG can also be estimated from the net energy available for gain. Thus, we have compared EBG estimates from BR-CORTE and NASEM for animals with 440 kg of SBW and using 6 Mcal/d NE*g*. For BR-CORTE, calculated EBG was 1.12 kg/d ($EBG = 14.914 \times 6^{0.9662} \times 388^{-0.7246}$), whereas NASEM's estimated EBG was 1.07 kg/d $\{(EBG = 12.341 \times [6/(0.891 \times 440)^{0.75}]^{0.9116})\}$. Therefore, BR-CORTE system estimates an EBG 5.2% greater for Zebu cattle compared to NASEM

Table 2. Energy requirements for growing and finishing cattle calculated based on BR-CORTE (2016) and NASEM (2016) systems

	BR-CORTE (2016)						NASEM (2016)					
	Zebu			Crossbred beef			*Bos taurus taurus* + Nellore			Zebu		
Item	Bull	Steer	Heifer	Bull	Steer	Heifer	Bull	Steer	Heifer	Bull	Steer	Heifer
BW, kg	449	373	344	489	417	357	789	482	482	789	482	482
ADG, kg	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80
DMI, kg	10.2	9.2	8.8	11.1	10.3	9.6	18.3	11.2	11.2	18.3	11.2	11.2
Diet ME, Mcal/kg	2.96	2.96	2.96	2.96	2.96	2.96	2.96	2.96	2.96	2.96	2.96	2.96
SRW, kg	517	517	517	517	517	517	478	478	478	478	478	478
SBW, kg	440	364	335	477	407	348	758	463	463	758	463	463
Mature SBW, kg	—	—	—	—	—	—	900	550	550	900	550	550
Mature EBW, kg	517	433	402	560	482	417	802	490	490	802	490	490
EQSBW, kg	—	—	—	—	—	—	402	402	402	402	402	402
EBW, kg	388	325	302	420	362	313	675	413	413	675	413	413
EQEBW, kg	388	388	388	388	388	388	359	359	359	359	359	359
EQEBW/SRW	**0.75**	**0.75**	**0.75**	**0.75**	**0.75**	**0.75**	**0.75**	**0.75**	**0.75**	**0.75**	**0.75**	**0.75**
EBG, kg	1.75	1.75	1.75	1.75	1.75	1.75	1.72	1.72	1.72	1.72	1.72	1.72
NE*m*, Mcal/d	6.55	5.74	5.43	6.96	6.22	5.58	8.84	7.69	7.69	7.95	6.92	6.92
NE*g*, Mcal/d	9.51	9.51	9.51	9.51	9.51	9.51	9.49	9.49	9.49	9.49	9.49	9.49
NE, Mcal/d	16.1	15.2	14.9	16.5	15.7	15.1	18.3	17.2	17.2	17.4	16.4	16.4
K*m*	0.77	0.77	0.77	0.72	0.72	0.72	0.68	0.68	0.68	0.68	0.68	0.68
K*g*	0.46	0.46	0.46	0.46	0.46	0.46	0.45	0.45	0.45	0.45	0.45	0.45
ME*m*, Mcal/d	8.53	7.47	7.07	9.65	8.63	7.74	13.1	11.4	11.4	11.8	10.2	10.2
ME*g*, Mcal/d	20.5	20.5	20.5	20.5	20.5	20.5	20.9	20.9	20.9	20.9	20.9	20.9
ME*t*, Mcal/d	29.0	28.0	27.6	30.2	29.1	28.2	34.0	32.3	32.3	32.7	31.1	31.1
DE, Mcal/d	34.0	32.5	32.0	35.4	34.1	33.0	41.4	39.3	39.3	39.8	38.0	38.0
TDN, kg	7.72	7.39	7.27	8.05	7.75	7.49	9.42	8.94	8.94	9.05	8.63	8.63

DMI = dry matter intake; ME = metabolizable energy; EQSBW = equivalent shrunk body weight; NE = net energy requirement; K*m* = efficiency of use of NE*m*; K*g* = efficiency of use of NE*g*; ME*t* = total metabolizable energy requirement; DE = digestible energy requirement; TDN = total digestible nutrients requirement.

Table 3. Summary of the equations used to estimate energy requirements for lactating beef cows in Table 4

Item	BR-CORTE (2016)	NASEM (2016)
SBW, kg	$0.88 \times BW^{1.0175}$	$0.96 \times BW$
EBW, kg	$0.8507 \times SBW^{1.0002}$	$0.891 \times SBW$
NE*m*, Mcal/d	$0.0978 \times EBW^{0.75}$	$0.077 \times SBW^{0.75} \times L$
ME*m*, Mcal/d	$0.135 \times EBW^{0.75}$	NE*m*/K*m*
K*m*	NE*m*/ME*m*	NE*ma*/ME
NE*p*, Mcal/d	$[CBW \times (0.000000793 \times DP^{3.017})]/1{,}000$	$[CBW \times (0.05855 - 0.0000996 \times PD) \times e^{(0.0323 \times PD - 0.0000275 \times PD^2)}]/1{,}000$
K*p*	0.12	0.13
EM*p*, Mcal/d	NE*p*/K*p*	NE*p*/K*p*
NE_l, Mcal/kg milk	0.75	0.72
NE_l, Mcal/d	NE*milk* × milk yield	NE*milk* × milk yield
K_l	K_l = K*m*	K_l = K*m*
ME_l, Mcal/kg milk	NE*milk*/K_l	NE*milk*/K_l
ME_l, Mcal/d	EL*l*/K_l	EL*l*/K_l
NE*t*, Mcal/d	NE*m* + NE*p* + NE_l	NE*m* + NE*p* + NE_l
ME*t*, Mcal/d	ME*m* + ME*p* + ME_l	ME*m* + ME*p* + ME_l

L = lactating factor (1.2 for Nellore cows); K*m* = efficiency of use of ME*m* to NE*m*; NE*ma* = net energy for maintenance available in the diet, calculated as $NE_{ma} = 1.37 \times ME - 0.138 \times ME^2 + 0.0105 \times ME^3$, where ME is dietary metabolizable energy; NE*p* = net energy requirement for pregnancy; CBW = calf birth weight (kg); DP = days pregnant; K*p* = efficiency of use of ME*p* to NE*p*; ME*p* = metabolizable energy requirement for pregnancy; NE_l = net energy requirement for lactation; K_l = efficiency of use of ME_l to NE_l; ME_l = metabolizable energy requirement for lactation; NE*t* = total net energy requirement; ME*t* = total metabolizable energy requirement.

in this example. These results might be related with differences in marbling from American and Brazilian genotypes.

Table 4. Energy requirements for beef cows in different stages of pregnancy and milk yield calculated based on BR-CORTE (2016) and NASEM (2016) systems

	System	
Item	BR-CORTE (2016)	NASEM (2016)
BW, kg	500	500
SBW, kg	491	480
EBW, kg	418	428
CBW, kg	32	32
Requirements		
NE*m*, Mcal/d	9.04	9.48
ME*m*, Mcal/d	12.5	16.5
NE*p*, Mcal/d		
180 d pregnant	0.16	0.18
210 d pregnant	0.26	0.32
ME*p*, Mcal/d		
180 d pregnant	1.35	1.37
210 d pregnant	2.14	2.43
NE_l, Mcal/d		
5 kg milk	3.75	3.60
8 kg milk	6.00	5.76
ME_l, Mcal/d		
5 kg milk	5.21	6.25
8 kg milk	8.33	10.0
Efficiency of use of ME to NE		
K*m*	0.72	0.58
K*p*	0.12	0.13
K_l	0.72	0.58

CBW = calf birth weight; ME*p* = metabolizable energy requirement for pregnancy; NE_l = net energy requirement for lactation; ME_l = metabolizable energy requirement for lactation; K*m* = efficiency of use of ME*m* to NE*m*; K*p* = efficiency of use of ME*p* to NE*p*; K_l = efficiency of use of ME_l to NE_l; ME_l = metabolizable energy for lactation.

Pregnancy and Lactation Beef Cows

A summary of the equations proposed by BR-CORTE (2016) and NASEM (2016) systems for estimating energy requirements of pregnancy and lactation beef cows is presented in Table 3. An example of the net and metabolizable energy requirements estimated by both systems is presented in Table 4. In this example, a Nellore cow with 500 kg BW, gestating a calf with estimated 32 kg of calving weight, with different days of pregnancy (180 and 210 d) and milk yields (5 and 8 kg), was considered.

The NE*m* estimated by the NASEM (9.48 Mcal/d) system was approximately 5% greater than the value estimated by BR-CORTE (9.04 Mcal/d), whereas the ME*m* estimated by NASEM (16.5 Mcal/d) was approximately 32% greater than BR-CORTE estimation (12.5 Mcal/d). The lower K*m* considered by NASEM (0.58) compared to BR-CORTE (0.72) may help to explain the greater ME*m* values obtained when NASEM system is used.

With regard to requirements for pregnancy, greater net energy requirements for pregnancy (NE*p*) were estimated by NASEM system when compared to BR-CORTE. The NASEM NE*p* estimates for 180 and 210 d pregnant cows were approximately 12.5% and 23% greater than BR-CORTE system estimates, respectively. In addition, it should be noted that the magnitude of differences between these systems regarding NE*p* increased as pregnancy days increased (Figure 3). As the efficiencies of use of energy for pregnancy (K*p*) were similar between both systems (K*p* = 0.12 and 0.13 for BR-CORTE and NASEM, respectively), the

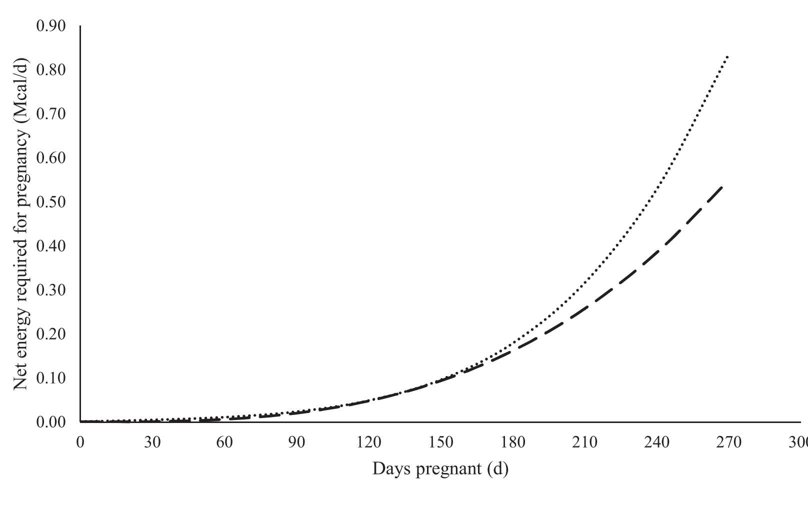

Figure 3. Net energy requirements for pregnancy of a Nellore cow carrying a calf with estimated 32 kg calving weight calculated based on BR-CORTE (2016) and NASEM (2016) systems.

magnitude of differences between them was maintained when the metabolizable energy requirements for pregnancy were estimated.

Considering an average milk composition, similar net energy requirements for lactation were obtained from NASEM or BR-CORTE systems (0.72 and 0.75 Mcal/kg milk, respectively). However, these systems considered different efficiencies of use of metabolizable energy for lactation (0.58 and 0.72 for NASEM and BR-CORTE systems, respectively). Therefore, the metabolizable energy requirement for lactation estimated by NASEM was approximately 19% greater than that estimated by BR-CORTE (1.24 and 1.04 Mcal/kg milk, respectively).

CONCLUSIONS

The BR-CORTE uses EBW to predict net energy for maintenance, which is predicted from different nonlinear equations for genotype, gender, and production systems, and does not consider differences of gender or genotype on net energy for maintenance. A Nellore steer of 450 kg in BR-CORTE has about 8% lesser NE*m* than an Angus steer of the same weight in CNES and NASEM systems.

The NE*g* is slightly smaller in BR-CORTE than in NASEM, because of differences in beef marbling and mature weight considered. The prediction of EBG is greater for BR-CORTE than that for NASEM, when the same metabolizable energy for gain is available.

The net energy for maintenance of a Zebu cow estimated by BR-CORTE was slightly lower than that estimated by NASEM system, whereas greater efficiency of use of energy for maintenance was considered by BR-CORTE compared with NASEM. Lower estimates of net K*p* were observed using BR-CORTE system compared to NASEM. The NASEM and BR-CORTE systems presented similar values for net energy for lactation. However, as BR-CORTE presented greater efficiency of use of energy for lactation than NASEM, the metabolizable energy for lactation (Mcal/kg milk) estimated by NASEM was greater than that estimated by BR-CORTE system.

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