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Feed intake and prediction assessments using the NRC, CNCPS and BR-CORTE systems in Nellore and Red Norte steers finished in feedlot

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ABSTRACT - The objective of this research was to evaluate the dry matter intake (DMI) and nutrient consumption in Nellore and Red Norte steer finished in a feedlot and compare the actual and predicted values by NRC (2000), CNCPS 5.0 and BR-CORTE systems. Forty-one animals, 19 Nellore and 22 Red Norte steers, with initial live weight of 361 ± 31 kg and 367 ± 30 kg, respectively, were used. The experiment lasted 84 days, with 28 days for adaptation and 56 experimental days. The animals were weighed at the beginning and at end of each 28-day period after 16 hours fasting. The dry matter intake was estimated by LIPE, chrome oxide and indigestible dry matter (DMi) markers. There were no differences between Nellore and Red Norte DMI when expressed in kg/day (10.66 vs. 10.44). When intake was expressed in percentage of live weight (% LW), Nellore steer presented higher intake than Red Norte steer (2.55 vs. 2.39%). All the systems evaluated presented a lower predicted intake than the observed intake. However, these differences were smaller for crossbreed animals.

Key Words: crossbreeding, markers, nutritional requirements, zebu breeds

Consumo alimentar e avaliação das predições pelos sistemas NRC, CNCPS e BR-CORTE em novilhos Nelore e Red Norte terminados em confinamento

RESUMO - Este trabalho foi realizado com os objetivos de avaliar o consumo de matéria seca (CMS) e dos nutrientes da dieta em novilhos Nelore e Red Norte terminados em confinamento e comparar os valores observados aos preditos por meio dos sistemas NRC (2000), CNCPS 5.0 e BR-CORTE. Utilizaram-se 41 novilhos, não-castrados, de dois grupos genéticos, sendo 19 Nelore com peso vivo inicial médio de 361 ± 31 kg e 22 Red Norte com peso vivo inicial de 367 ± 30 kg. No início do período de adaptação, com duração de 28 dias, os animais foram pesados após jejum alimentar de 16 horas e tratados contra endo e ecto parasitas. O período experimental teve duração de 56 dias e, além das pesagens nestes períodos, foram realizadas mensurações do consumo individual, utilizando-se os indicadores LIPE, óxido crômico e matéria seca indigestível (MSi). A comparação entre os dados de consumo observados com aqueles preditos pelos sistemas NRC (2000), CNCPS 5.0 e BR-CORTE foi feita por meio do procedimento PROC REG do *software* SAS. O consumo de matéria seca expresso em kg/dia não apresentou diferenças entre os grupos genéticos (10,66 vs 10,44). Quando expresso em porcentagem do peso vivo (%PV), o consumo foi maior para os animais da raça Nelore (2,55 vs 2,39%, respectivamente) e, quando expresso em g/kg $PV^{0,75}$, tendeu a ser maior para a raça Nelore (115 vs 109 g/kg $PV^{0,75}$). Todos os sistemas avaliados subestimam o consumo de matéria seca, entretanto há menores diferenças entre o consumo observado e o predito para animais mestiços.

Palavras-chave: cruzamento, exigências nutricionais, indicadores, zebuínos

Introduction

The productive response of animals depends on the intake, digestibility and metabolism of the diet nutrients. Dry matter intake is fundamental in animal feeding, because the total quantity of nutrients that the animal receives for production, health and reproduction depend on it (Coelho da Silva, 2006). With accurate dry matter intake estimates, more efficient diets can be formulated that fully meet the nutritional requirements of the animals, avoiding excess or absence of a determined nutrient.

Several models have been developed to predict cattle dry matter intake: the NRC (2000) and CNCPS 5.0 are the most used currently, but they were developed under different conditions from those found in Brazil, especially regarding the feed used to obtain the prediction equations and the climatic conditions.

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Valadares Filho et al. (2006a) stated that the NRC (2000) equations are inadequate to predict beef cattle dry matter intake in a feedlot when fed under tropical conditions, regardless of the breed group, weight gain rate or gender. Recently, the BR-CORTE (Valadares Filho et al., 2006b) system was released that uses databanks and genetic material representative of the Brazilian conditions for more accurate predictions of the dry matter intake for zebu breeds and their crossbreeds. However, the equations proposed by this system still need to be validated.

The individual intake of the animals must be measured to validate the intake prediction equations. Individual intake can be measured in three ways: by using electronic systems (*Calan Gates* or *Grow-Safe*) that are expensive to implant; using individual pens that, although efficient, is an experimental alternative that damages animal performance and alters the natural intake pattern in group by cattle (Valadares Filho et al., 2006a); and the use of intake markers, that has a cost compatible with the Brazilian reality.

Thus the objectives of this study were to assess the dry matter and nutrient intake in Nellore and Red Norte steer finished in a feedlot and to assess the DM intake prediction equations by the NRC, CNCPS 5.0 and BR-CORTE systems.

Materials and Methods

Forty-one intact steer were used from two genetic groups: 19 Nellore, with 361 ± 31 kg initial live weight and 22 Red Norte (½ Senepol, ¼ Caracu, ¼ F1 Angus-Nellore) with 367 ± 30 kg initial live weight. The mean initial age of these genetic groups was 20 months. The animals were confined in collective stalls with an area of 30 m^2 per animal, separated according to the genetic group. The feedlot installation had a compacted dirt floor, the area close to the feeder was covered with concrete and had wire divisions. The collective drinkers were located on the division of two stalls and vinyl type feeders were used, placed transversely on the upper part of the pens, with 70 cm for each animal.

At the beginning of the adaptation period, that lasted 28 days, the animals were weighed after a 16-hour fast and treated for ecto and endoparasites. During the adaption, they fed freely on the same feed as in the experimental period.

The experimental period consisted of two 28-day periods. At the end of each period, feces were collected for later analysis of the markers and to determine the dry matter intake estimate.

The diet was balanced to meet the requirements according to the NRC (2000) (Table 1), and was supplied freely in the form of complete diet, at 8 a.m. and 3 p.m. The leftovers were collected the following morning and the quantity adjusted daily to allow 5% leftovers. Concentrate and silage samples were collected every 14 days, that formed a compound sample. After pre-drying in a forced air ventilation chamber at 65° for 72 hours, the samples were ground in a grinder with a 1 mm mesh. The dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE), neutral detergent fiber corrected for ash and protein (NDFap) and acid detergent fiber (ADF) were determined according to Silva & Queiroz (2002).

The nonfibrous carbohydrates (NFC) were obtained according to Sniffen et al. (1992) and the TDN, according to the NRC (2001). The fecal production was estimated by the LIPE® indicator, one 0.5g capsule animal/day (Saliba, 2005), on days 24, 25 and 26 of each experimental period. The feces were collected according to Ladeira et al. (1999), at 10 a.m. and 6 p.m. on day 25. 8 a.m. and 4 p.m. on day 26 and 6 a.m. and 2 p.m. on day 27. The samples were pre-dried in a forced air chamber at 65°C for 72 hours and ground in a grinder with a 1 mm mesh, and a compound sample was made for each animal, in each period, based on the dry weight of each collection.

To determine the concentrate intake, chrome oxide was used mixed to the concentrate at the proportion of 10 g/animal/day, supplied to the animals between the 19th and 27th day of the two experimental periods. To determine the roughage intake, the DMi was used obtained 240 hours after ruminal incubation according to the technique reported by Casali et al. (2008). Roughage and concentrate samples were collected on all the days chrome oxide was supplied.

Table 1 - Ingredients and nutritional composition of the experimental feed

Ingredient	Composition (%DM)
Corn silage	50.0
Whole ground corn	23.0
Peleted citrus pulp	11.5
Soybean meal 46% CP	10.0
Cotton meal 8% CP	3.4
Urea	0.5
Mineral nucleus[1]	1.6
Nutrient	
Dry matter[2]	47.7
Crude protein[3]	14.3
Neutral detergent fiber (NDFap)[3]	30.1
Non-fibrous carbohydrates[3]	47.9
Ether extract[3]	3.0
Total digestible nutrients[3,4]	70.3

[1] Guaranteed levels per kilogram product: Ca: 235 g; P: 45 g; S: 23 g; Na: 80.18 g; Zn: 2.38 mg; Cu: 625 mg; Fe: 1.18 mg; Mn: 312 mg: Co: 32 mg; I: 41.6 mg; Se: 11.25 mg; vit. A: 70.000 UI; vit. D3: 5.000 UI; vit. E: 15 UI; niacin: 3.33 mg.
[2] Natural matter base.
[3] Dry mater base.
[4] Calculated according to NRC (2001).

Part of the feces samples was sent to the Veterinary Medicine College at the Federal University of Minas Gerais for the LIPE® analyses by the methods by Sarkanen & Ludwig (1971). The chromium analyses were carried out according to the technique reported by Savastano et al. (1993).

The statistical analyses for the intake data were performed using the F test of the GLM procedure of the SAS statistical software (SAS, 1999). A linear regression analysis was used to compare the values predicted by the NRC, CNCPS5.0 and BR-CORTE systems to the observed values, using the SAS statistical software (SAS, 1999). According to the nil hypothesis the predicted values were considered statistically equal to those observed if the intercept and the slope coefficient were equal to 0 and 1. respectively. If the nil hypothesis was rejected, the values predicted by the nutritional requirement systems differed statistically from those observed.

As the Red Norte compound is formed by four breeds and the NRC and CNCPS5.0 systems accept the inclusion of only three, the Santa Gertrudes, Nellore and Red Angus breeds were used. The Senepol breed was not included because it is not a part of these nutritional requirement systems, thus, the Santa Gertrudes breed was used, that can be used in the formation of a Red Norte compound.

Results and Discussion

The dry matter intake, when expressed in kg/day, was not different (P>0.5) among the Nellore and Red Norte animals (Table 2). Similar results were obtained by Goulart (2008), who did not observe differences in the dry matter intake (10.74 kg/day) of Nellore cattle, ½ Canchim-Nellore and ½ Simental-Nellore. In experiments carried out over many years, Horrocks & Philips (1961) and Hunter & Siebert (1985) concluded that dry matter ingestion did not vary among zebu and European breeds and their crossbreeds.

However, other researchers have observed difference in dry matter intake among zebu and European breeds and crossbreeds. Frisch & Vercoe (1977) and Ledger et al. (1970) demonstrated that animals of the Brahman breed and Brahman × British breeds presented smaller dry matter intake than pure British breed animals. Oliveira et al. (1994) observed smaller intake for Nellore animals compared to crossbred animals fed 30 or 50% concentrate.

When the intake was expressed in grams per kilo live metabolic weight (g/kg $LW^{0.75}$) a greater tendency was observed for high intake for the Nellore breed animals (P = 0.09). However, when the live weight percentage (%LW) was considered, there was difference among the genetic groups (P>0.5) so that animals of the Nellore breed presented greater intake compared to those of the Red Norte breed. The greater intake in %LW for Nellore animals occurred because these animals presented lower live weight compared to those of the Red Norte breed in the period when the intake was obtained, because the daily weight gain was different (1.53 vs 1.88 kg/day, respectively).

According to Forbes (1995), the body fat percentage, that is usually greater in heavier weights, affects foodstuff ingestion because with the increase in the live weight, there are alterations in the body composition and a greater accumulation of adipose tissue in the abdominal region that physically limits the capacity to accommodate the digestive tract, so that intake is reduced. Another cause would be the effect of feedback of the adipose tissue on intake control (Silva et al., 2002). The intake/metabolic weight unit starts to decrease at around 350 kg weight in a medium sized steer (NRC, 1987). Silva et al. (2002) researched intact the Nellore steer and observed a decreasing linear effect of the live weight on dry matter intake. The smaller dry matter intake observed in the Red Norte breed may have resulted from the greater weight gain observed and the greater live weight at the time of the assessments.

The roughage and concentrate intake, in both the breeds, was around the roughage:concentrate ratio of the

Table 2 - Dry matter intake in Nellore and Red Norte steer finished in a feedlot

Item	Breed				
	Nellore	SD	Red Norte	SD	P
Dry matter (kg/day)	10.66	0.22	10.44	0.20	0.46
Dry matter (% LW)	2.55	0.05	2.39	0.05	0.05
Dry matter (g/kg $LW^{0.75}$)	115.05	2.36	109.40	2.19	0.09
Concentrate dry matter (kg/day)	5.62	0.13	5.52	0.12	0.58
Roughage dry matter (kg/day)	5.04	0.10	4.89	0.09	0.30
Concentrate dry matter (%DM)	52.71	0.50	52.78	0.47	0.92
Roughage dry matter (%DM)	47.32	0.54	46.97	0.50	0.64

Means in a line followed by a different letter differ (P<0.05) by F test.
SD = Standard deviation.

diet, showing that the animals selected the feed, that is expected when working with 5% leftovers and feed with 50% roughage, because zebu breed animals tend to reject the concentrate in feed with 30% or less roughage.

The crude protein intake in kg/day did not differ among the genetic groups studied (P>0.5) (Table 3), that was expected, because there was no difference in dry matter intake in kg/animals/day and the feed was the same for both the groups. According to Valadares Filho et al. (2006b), crude protein intake should be sufficient for gains greater than 1.5 kg/day.

Considering the NRC (2000) recommendation for animals with approximately 419 kg live weight, the crude protein intake observed was sufficient to meet the protein requirements of the Nellore steer, because the system aims for a mean daily gain of 1.5 kg/day intake of 1.11 kg/CP/day.

For the Red Norte animals, with average 436 kg live weight, the NRC (2000) recommends a crude protein intake close to 1.15 kg/day for 1.8 kg/day weight gain. Therefore the intakes observed were sufficient to meet the protein requirements for maintenance and weight gain. According to the results obtained, it can be stated that the crude protein content of the feed used in the experiment was above the animal requirements. According to the BR-CORTE system, with animals approximately 400 kg live weight, the feed CP content should be 13.7% while the NRC method recommends for animal with live weight around 400 kg, crude protein feed content of approximately 10.7%.

The Nellore and Red Norte animals presented NDT intake of 7.5 and 7.3 kg/day, respectively. According to the BR-CORTE system, for animals of approximately 400 kg, the total requirement (maintenance + weight gain) of total digestible nutrients to allow mean daily gain of 1.50 kg is 6.18 kg NDT for intact males. Thus, the total digestible nutrient intake was higher than that recommended by the system, or the requirement for gain was overestimated.

The insoluble neutral detergent fiber intake in kg/day did not differ between the genetic groups (P>0.5) but when the intake was expressed in live weight percentage, it was different (P>0.5) and so was the dry matter intake. According to the equation proposed by Detmann et al. (2003) to estimate insoluble neutral detergent fiber intake by cattle in feedlot, considering the roughage proportion in the feed, the estimated insoluble neutral detergent fiber intake would be 3.78 kg and 3.93 kg/day for Nellore and Red Norte steer, respectively. The difference between the values estimated by the equation with those observed proved that this equation can be used only as a reference in the calculation of the dry matter intake. Insoluble neutral detergent fiber of 0.73 and 0.68% of the live weight for Nellore and Red Norte steer, respectively, suggested that the dry matter intake was controlled by the energy demand because values found were lower than 1.2% of the %LW, a value suggested by Mertens (1994). The ether extract intake (kg/day) was not different (P>0.5) between the genetic groups.

According to the NRC, the methods described to predict dry matter intake are planned to give general guidance, because there is no equation that can be applied in all production situations. According to Valadares Filho et al. (2006a), it would be correct to develop equations to predict dry matter intake specific for a determined production situation, but the use of fitted factors may be more practical to improve the accuracy of these equations. The dry matter intake means predicted by the NRC, CNCPS5.0 and BR-CORTE nutritional requirement systems were lower than the observed dry matter intake observed (Table 4).

The regression analyses of the dry matter intake predictions, carried out by the nutritional requirement systems, showed from the values of the intercept and slope, that all the systems presented low accuracy in predicting for the Nellore and Red Norte breeds (Figures 1 and 2; Tables 5 and 6).

The observed dry matter intake means and those predicted by the NRC (2000) for the Nellore animals were underestimated by 17% (Table 3). Gesualdi Jr. et al. (2005) studied selected Nellore steer and observed that this system

Table 3 - Intakes of crude protein, neutral detergent fiber and ether extract in Nellore and Red Norte steer finished in feedlot

Item	Nellore	SD	Red Norte	SD	P
Crude protein (kg/day)	1.36	0.03	1.34	0.03	0.46
Crude protein (%LW)	0.32	0.01	0.31	0.01	0.05
Crude protein (g/kg $LW^{0.75}$)	14.68	0.33	14.04	0.31	0.09
Neutral detergent fiber (kg/day)	3.06	0.06	2.98	0.06	0.46
Neutral detergent fiber (%LW)	0.73	0.02	0.68	0.01	0.05
Neutral detergent fiber (g/kg $LW^{0.75}$)	33.04	0.71	31.23	0.66	0.09
Ether extract (kg/day)	0.33	0.01	0.32	0.01	0.46
Ether extract (%LW)	0.08	0.02	0.07	0.01	0.05
Ether extract (g/kg $LW^{0.75}$)	3.57	0.07	3.38	0.06	0.09

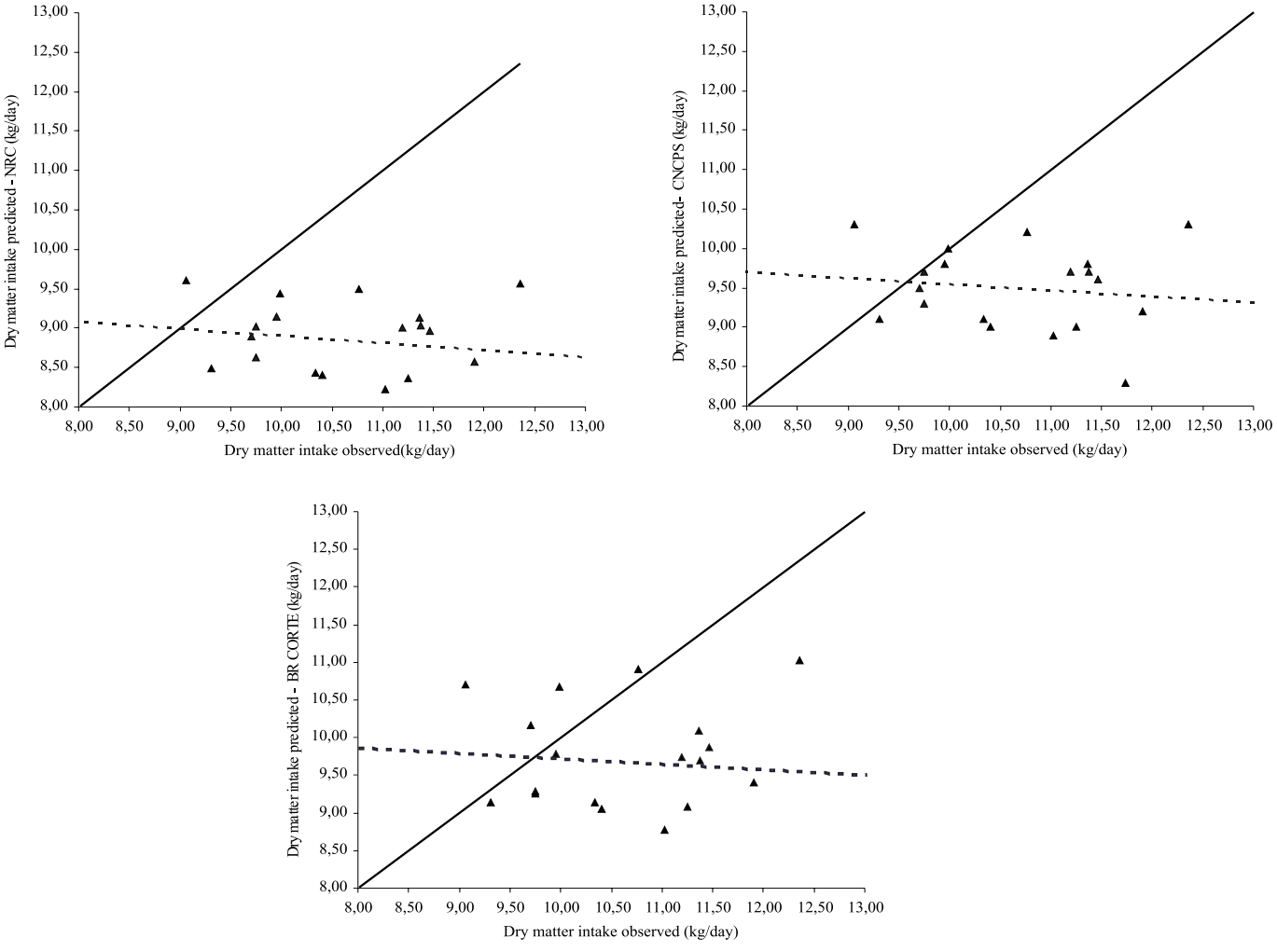
Means in a line, followed by the same letter, are different (P>0.05) by F test (kg/day, intake in kilograms per day).
%LW: intake in percentage live weight; g/kg$LW^{0.75}$: intake, in grams per kilogram of metabolic live weight.
SD = Standard deviation.

presented 10% lower dry matter intake prediction. For the animals of the Red Norte breed, the prediction by the NRC system was 11.3% lower, a value similar to that reported by Gesualdi Jr. et al. (2005) for the Caracu breed for which the prediction by the system was 13.6% or less.

In the evaluation of the CNCPS 5.0 system, the dry matter intake prediction for the Nellore breed was 10.9% lower while for the Red Norte breeds, the predicted dry matter intake was 5.30% lower. Cappelle et al. (2001) assessed the dry matter intake prediction for crossbred cattle kept on feed with 50% concentrate and obtained a prediction for ½ Nellore × Marchigiana, 23% lower and for ½ Nellore × Limousin animals, 30% lower. Jorge et al. (1997) studied Nellore cattle and ½ Holandês × Nellore steer fed

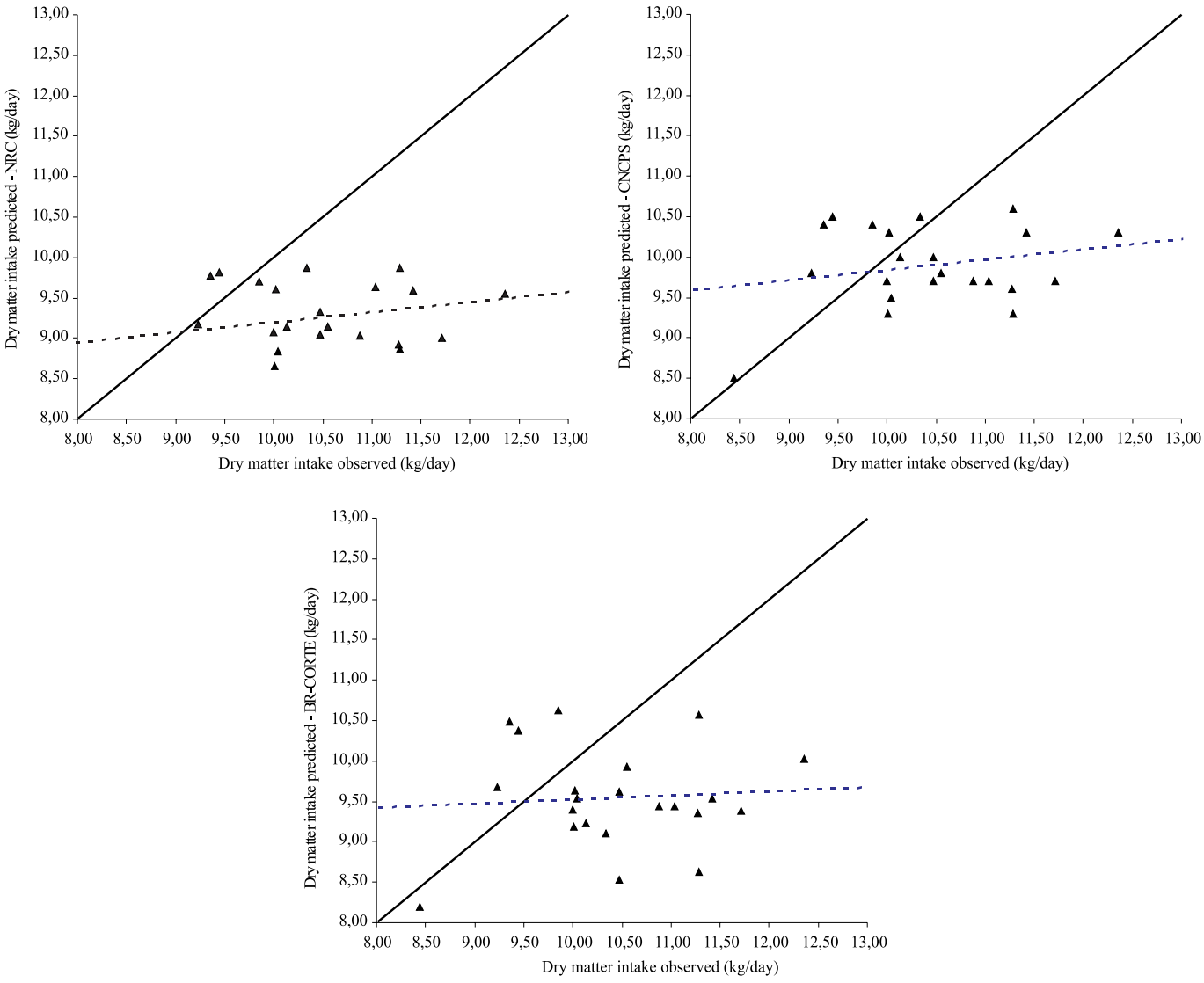
Table 4 - Observed and predicted dry matter intakes by the NRC, CNCPS5.0 and BR-CORTE systems

	Observed				Predicted NRC (2000)			
	Least	Mean	Highest	CV	Lowest	Mean	Highest	CV
Nellore	9.10	10.66	12.40	8.87	7.65	8.85	9.61	5.94
R.Norte	8.50	10.44	12.40	9.24	7.98	9.26	9.87	5.05
	Predicted CNCPS				Predicted BR-CORTE			
	Lowest	Mean	Highest	CV	Lowest	Mean	Highest	CV
Nellore	8.3	9.50	10.30	5.70	7.83	9.66	11,02	8.58
R.Norte	8.5	9.89	10.50	5.09	8.20	9.54	10.63	6.76



Line represents X = Y; dots represent the observed values and dotted line represents the regression equation

Figure 1 - Observed dry matter intakes and those predicted by the NRC, CNCPS5.0 and BR-CORTE nutritional systems for the Nellore breed (kg/day).



Line represents X = Y; dots represent the observed values and dotted line represents the regression equation.

Figure 2 - Observed dry matter intake versus predicted by the nutritional systems for the Red Norte breed (kg/day).

Table 5 - Regression of the observed dry matter intake values and those predicted by the NRC, CNCPS5.0 and BR-CORTE systems for the Nellore breed

		Inclination			Intercept		
System	r^2a	Value	SD	P	Value	SD	P
NRC (2000)	-0,0301	-0,09011	0,130	<0,01	9,807	1,401	<0,01
CNCPS	-0,0390	-0,07674	0,134	<0,01	10,318	1,444	<0,01
BR-CORTE	-0,0513	-0,07212	0,206	<0,01	10,433	2,213	<0,01

Table 6 - Regression of the observed dry matter intake values and those predicted by the NRC, CNCPS5.0 and BR-CORTE for the Red Norte breed

		Inclination			Intercept		
System	r^2a	Value	SD	P	Value	SD	P
NRC (2000)	0.0116	0.12409	0.111	<0.01	7.95	1.164	<0.01
CNCPS	0.0060	0.12703	0.119	<0.01	8.56	1.253	<0.01
BR-CORTE	-0.0443	0.05078	0.153	<0.01	9.010	1.607	<0.01

50% concentrate and observed that the CNCPS5.0 system presented intake prediction 21 and 17% lower, respectively.

The BR-CORTE system presented intake prediction for the Nellore breed 9.4% lower. For the Red Norte breed animals, the dry matter intake prediction was 8.6% less in this system.

All the systems assessed presented smaller differences between the observed and predicted intake for the crossbred animals, that suggested that the crossbred animals tended to present intakes closer to those predicted by the systems, a fact also observed by the analysis of the regression equations. The results of this equation presented responses similar to those observed by other authors (Souza, 1987; Galvão, 1991; Jorge et al., 1997; Ferreira et al., 1997) who assessed the main nutritional requirement systems used in Brazil and observed that the intake predicted by the systems tended to be lower than the observed intake. In all the experiments mentioned above, the experimental feed contained 50% concentrate except in the study by Souza (1987), in which the experimental animals were kept on a diet with 20% concentrate.

Conclusions

Animals of the Nellore breed presented dry matter intake in %LW greater than those of the Red Norte breed. The NRC (2000), CNCPS5.0 and BR-CORTE nutritional requirement systems underestimated the dry matter intake in the Nellore and Red Norte genetic groups.

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