

Correlations between feed efficiency and ingestive behavior of Nellore breed bulls housed in collective pens equipped with electronic feed bunks

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Summary

The evaluation of ingestive behavior in beef cattle allow a better understanding of the mechanisms that involve the variations in the efficiency of food utilization, based on the energy expenditure of the animals, making it possible to identify the feeding patterns of more efficient and less efficient animals. Thus, the aim of this study was to evaluate the associations between feed efficiency and ingestive behavior of 603 Nellore bulls housed in collective pens equipped with electronic feed bunks. The animals received a total mixed ration containing 70 % of total digestible nutrients and 14 % of crude protein for 56 days to obtain dry matter intake (DMI) and average daily gain (ADG) data to calculate the residual feed intake (RFI), feed conversion ratio (FCR) and gross feed efficiency (GFE). The behavioral variables were obtained by the electronic monitoring system of the automatic feed bunks, being evaluated the total time in trough (TT), feeding time (FT), total visits (TV), visits with and without feed intake (VI and VwI) and feed rates per hour and per visit. Pearson simple correlations were estimated through CORR procedure of SAS and were considered significant when $P < 0.05$. The final live weight (FLW), metabolic live weight ($MLW^{0.75}$) and ADG presented weak positive phenotypic correlations with feed rates per hour (0.36, 0.34 and 0.13, respectively) and per visit (0.23, 0.22 and 0.10, respectively). Weak positive correlations were observed between observed dry matter intake (DMI_{obs}) and TT (0.09), FT (0.09), TV (0.24), VI (0.23) VwI (0.17) and feed rate per hour (0.45). The DMI calculated on the basis of live weight ($DMI \% LW$) was positively correlated to TT (0.13), FT (0.14), TV (0.31), VI (0.32), VwI (0.17), feed rate per hour (0.15) and it was negatively associated with the feed rate per visit (-0.21). The RFI presented weak positive correlations with TV (0.14), VI (0.14), VwI (0.11) and feeding rate per hour (0.26). The FCR showed weak positive correlation with feed rate per hour (0.09), while the GFE was negatively associated with TV (-0.14), VI (-0.14), VwI (-0.08) and feeding rate per hour (-0.13). Feed efficiency measures such as residual feed intake and gross feed efficiency presents significant correlations with ingestive behavior characteristics of Nellore bulls in feedlot, being possible to observe a pattern of behavior of the more efficient animals for these measures.

Keywords: Bos indicus, dry matter intake, feeding rates, residual feed intake, weight gain

Introduction

About 70 % of the total energy intake in beef cattle is exclusively intended to meet the maintenance requirements of animals (NRC, 1996). Accordingly, selection based on classic efficiency measures, including feed conversion ratio and gross feed efficiency, may fail to improve whole-system efficiency. This is because such measures are strongly correlated with weight gain and live weight, thereby causing increases in both adult weight and maintenance requirements of animals, which raises the costs of maintaining dams in herds (Arthur *et al.*, 2001; Carstens *et al.*, 2002).

Residual feed intake (RFI) has been widely discussed and proposed as an advantageous alternative selection measure in production systems because it prioritizes low-intake and low-maintenance animals, without changing adult weight or weight gain, thereby considerably reducing production costs (Koch *et al.*, 1963). Furthermore, studies indicate that high-efficiency animals, based on the RFI, emit fewer pollutants per unit of meat produced, especially enteric methane (Nkrumah *et al.*, 2006). However, it is necessary to know better the biological processes related to variations in this feed efficiency measure.

The study of ingestive behavior of cattle is an important tool in the evaluation of RFI, since it allows a better understanding of the mechanisms that involve the variations in the efficiency of food utilization, based on the energy expenditure of the animals in activities such as the search of food, feeding, rumination and chewing and also allows the search for correlations of feeding habits of high and low-efficiency animals. Richardson & Herd (2004), reviewing the mechanisms related to RFI in beef cattle reported that up to 9 % of the variation in this efficiency measure can be explained by physical activity in the search of food and up to 2 % by the different feeding patterns of the animals.

In this context, the aim of this study was to evaluate the phenotypic correlations between feed efficiency and ingestive behavior characteristics of Nellore bulls housed in collective pens equipped with electronic feed bunks.

Material and methods

For the study, were analyzed data of 603 Nellore bulls participants of seven feed efficiency evaluation tests, performed on Embrapa Beef Cattle, Campo Grande, MS Brazil, between May of 2016 and July of 2017.

The animals, which presented age varying between 18 and 24 months, were housed in collective pens (20 m² per animal) equipped with electronic feed bunks (Intergado System, Belo Horizonte, MG, Brazil) for a total period of 70 days, being 14 days for adaptation to the installations and the diet and 56 days for collect of observed daily dry matter intake (DMI_{obs}) and average daily weight gain (ADG) data. In this period was provided a total mixed ration (TMR) containing 70 % of total digestible nutrients (TDN) and 14 % of crude protein (CP), composed by sorghum silage and balanced concentrate in a relation roughage:concentrate of 40:60. The supply were been realized ensuring the *ad libitum* consume by the animals.

The measures of feed conversion ratio (FCR) and gross feed efficiency (GFE) were calculated using the DMI_{obs} and ADG data. For calculation of the residual feed intake (RFI; Koch *et al.*, 1963), were obtained the DMI predicted values (DMI_{pred}) estimating the regression of DMI_{obs} in function of the metabolic live weight (MLW^{0,75}) and the ADG by the

REG procedure of SAS (version 9.2; 2008):

$$\text{DMI}_{\text{obs}} = \beta_0 + \beta_1 \times (\text{MLW}^{0.75}) + \beta_2 \times (\text{ADG}) + \varepsilon \quad (1)$$

The RFI of each animal were calculated by the difference between the DMI_{obs} and the DMI_{pred} .

The behavioral variables were obtained by the electronic monitoring system of the automatic feed bunks, being evaluated the total time in trough (TT), feeding time (FT), total visits (TV), visits with and without feed intake (VI and VwI) and, with this data, were calculated the feed rates per hour (rate/hr) and per visit (rate/visit).

Pearson simple correlations were estimated using the CORR procedure of SAS (version 9.2; 2008) and were considered significant when $P < 0.05$. The different significance levels for the phenotypic correlations obtained in the test were presented in the results according to the following notes: *($P < 0.05$); ** ($P < 0.01$) and *** ($P < 0.001$).

Results and discussion

The final live weight (FLW) and metabolic live weight ($\text{MLW}^{0.75}$) presented weak positive phenotypic correlations with feed rates per hour and per visit ($P < 0.001$), indicating that the heavier animals consume more food per hour and per visit to the trough. The average daily gain (ADG) was also positively associated with these rates ($P < 0.01$ and $P < 0.05$, respectively; Table 1).

There were also weak positive correlations between observed dry matter intake (DMI_{obs}) and total time in trough, feeding time ($P < 0.05$), total visits, visits with and without feed intake and feed rate per hour ($P < 0.001$). The DMI calculated on the basis of live weight (DMI %LW) was positively correlated to total time in trough ($P < 0.01$), feeding time, total visits, visits with and without feed intake and feed rate per hour ($P < 0.001$), on the other hand, it was negatively associated with the feed rate per visit ($P < 0.001$), indicating that due to the higher frequency of trough visits, the animals consumed less in each one (Table 1).

Table 1. Phenotypic correlations of performance and feed efficiency with ingestive behavior characteristics of Nelore bulls housed in collective pens equipped with electronic feed bunks.

Variables ^{1,2}	TT	FT	TV	VI	VwI	Rate/hr	Rate/v
FLW	-0.008	-0.01	-0.04	-0.05	0.04	0.36***	0.23***
$\text{MLW}^{0.75}$	-0.02	-0.02	-0.04	-0.05	0.03	0.34***	0.22***
ADG	0.07	0.07	0.00	-0.002	0.008	0.13**	0.10*
DMI_{obs}	0.09*	0.09*	0.24***	0.23***	0.17***	0.45***	0.03
DMI %LW	0.13**	0.14***	0.31***	0.32***	0.17***	0.15***	-0.21***
RFI	0.03	0.05	0.14***	0.14***	0.11**	0.26***	0.02
FCR	-0.05	-0.04	0.06	0.06	0.05	0.09*	-0.03
GFE	0.04	0.03	-0.14***	-0.14***	-0.08*	-0.13**	0.10*

¹FLW = final live weight, kg; $\text{MLW}^{0.75}$ = metabolic live weight, kg; ADG = average daily gain, kg day⁻¹; DMI_{obs} = observed dry matter intake, kg DM day⁻¹; DMI %LW = DMI in relation to live weight, %; RFI = residual feed intake, kg DM day⁻¹; FCR = feed conversion ratio; GFE = gross feed efficiency; TT = total time in trough, minutes; FT = feeding time, minutes; TV = total visits, n; VI = visits with feed intake, n; VwI = visits without feed intake, n; Rate/hr = feeding rate per hour kg DM hour⁻¹; Rate/v = feeding rate per visit, kg DM visit⁻¹.

²Pearson simple correlations, significance notes = *($P < 0.05$); **($P < 0.01$); ***($P < 0.001$).

Regarding to feed efficiency measures, the RFI presented weak positive correlations with the total visits to the trough ($P<0.001$), visits with or without feed intake ($P<0.001$ and $P<0.01$, respectively) and feeding rate per hour ($P<0.001$), suggesting that the more efficient animals (negative RFI), visits less the trough and feed slowly.

Robinson & Oddy (2004) also reported ingestive behavior characteristics positively associated to RFI, so that the more efficient steers were related to lower feeding time per day, less visits to the trough and lower feeding rate, consequently spending less amount of energy in these activities and directing better this energy to the tissue metabolism. Herd *et al.* (2004) observed that the high-RFI animals remained 13 % longer with food capture and chewing, with more energy wasted in these activities in relation to low-RFI animals.

The feed conversion ratio (FCR) showed weak positive correlation with feed rate per hour ($P<0.05$), while the gross feed efficiency (GFE) was negatively associated with total visits to the trough, visits with intake ($P<0.001$), visits without intake ($P<0.05$) and feeding rate per hour ($P<0.01$) indicating that the more efficient animals for this measure, as well as observed for RFI, visits less the trough and consume lower amount of food per hour.

Conclusion

Feed efficiency measures such as residual feed intake and gross feed efficiency presents significant correlations with ingestive behavior characteristics of Nellore bulls in feedlot, being possible to observe a pattern of behavior of the more efficient animals for these measures.

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