

Original Research Article

CORRELATION BETWEEN INTAKE AND INGESTIVE BEHAVIOR OF CONFINED HOLSTEIN-ZEBU CROSSBRED HEIFERS

ABSTRACT

The aim of the study was to evaluate the correlation between variables referring to feed intake and behavior of confined Holstein-Zebu crossbred heifers. The experiment was conducted at the dairy unit of the Southwest Bahia State University, *campus* Itapetinga, Brazil. Sixteen $\frac{3}{4}$ Holstein x $\frac{1}{4}$ Zebu heifers with average of 12 months old and initial weight of 150 kg were randomly distributed into four treatments, with four repetitions. A moderate positive correlation was observed between feeding time and NDF, and NFC intake variables. The feeding efficiency of NDF was highly correlated with DMI. The variables referring to time of feeding, rumination and boluses per day were observed to be highly correlated with the intake variables, thus showing great potential to draw up predictive equations.

KEYWORDS: ethology, intake, nutrition, rest, rumination

INTRODUCTION

The existence of correlation between nutrient intake, performance and animal behavior is unmistakable evidence that, if properly evaluated, animal behavior is a tool of extreme relevance for the understanding of the metabolic and nutritional aspects related to cattle production, thereby eliminating the need for invasive trials which, in many cases, do not meet the current welfare requirements to which we should subject the animals Silva et al. (2014). Thus, in order to improve the knowledge of daily food intake, it is necessary to study its individual components, which can be described by the number of meals consumed each day, the average duration of meals and consumption speed. All these processes result from the interaction between the animal's metabolism, and physical and chemical properties of the diet, which in turn stimulates the satiety receptors (Miranda et al., 1999).

Studies on the ingestive behavior of ruminants have increased over the last years (Missio et al., 2010; Silva et al., 2010; Pereira et al., 2009), as researchers need to distinguish and recognize the behavioral aspects,

which are directly related to the need for understanding the variation from diet responses. These variables are not well understood when individually evaluated, thus, they require behavioral observation.

It is necessary to improve methods that evaluate the consumption influence, so that both variables (animal and diet) can be defined and strategies developed to optimize the production process (Detmann et al. 2001).

Despite that not all intake variables are directly related to ingestive behavior, identifying those that can be highly correlated to it might generate subsidies for the establishment of models that can properly estimate consumption, without the need of invasive techniques. These techniques would alter the feeding behavior of animals and consequently reflect on their consumption and performance.

Fiber intake is one of the variables related to ingestive behavior that are highly correlated with the time allocated for rumination (Albright, 1993), whereas the consumption of concentrates and finely ground or pelleted hay is associated with reduced rumination time (Van Soest, 1994). The objective of this study was to evaluate the correlation between the variables referring to behavior and food intake by confined Holstein-Zebu crossbred heifers, which will help the development of models.

MATERIAL AND METHODS

Animal management and sampling

The experiment was conducted at the Cattle Farming Unit of Southwest Bahia State University from November 2004 to February 2005. Sixteen $\frac{3}{4}$ Holstein x $\frac{1}{4}$ Zebu heifers with average age of 12 months old and initial weight of 150 kg were randomly distributed into four treatments and four repetitions. The animals were kept in individual concrete-floored pens of 2.5 m². The experimental period lasted 70 days, with 14 days for adaptation. All observations were made on the last week of the experimental period.

The animals were fed a diet consisting of forage to concentrate ratio of a 60:40, based on dry matter content and diets were fed *ad libitum*. Elephant grass silage was replaced by 5, 10, 15 or 20% cassava bagasse. These levels corresponded to the four treatments, which were formulated to be iso nitrogenous. The concentrate contained corn, soybean meal, urea + ammonium sulfate and mineral mix (Table 1).

The chemical analysis of experimental diets and cassava bagasse were made as described by Silva and Queiroz (2002) and are presented in Table 2.

Food was provided twice a day at 7:00 a.m. and 04:00 p.m. and water was always available. The amount of food provided was adjusted according to the previous day's consumption, ensuring 5 to 10% leftovers. The amount of food provided and leftovers were daily removed and weighed individually.

Concentrates were sampled on a weekly basis. Silage and leftovers were sampled daily and pooled weekly. All samples (silage, concentrates and leftovers) were pre-dried in a forced ventilated oven at 65°C and ground in a 1 mm mesh sieve for subsequent laboratory analysis of dry matter (DM), neutral detergent fiber (NDF) and non-fiber carbohydrates (NFC).

Ingestive behavior

Feeding, rumination and resting observations were made for 48 consecutive hours, with intervals of five minutes (Gary et al., 1970). During night-time, artificial lighting was used. Feeding and rumination efficiencies were estimated as g DM/hour, g NDF/hour or g NFC/hour, ingested or ruminated.

Total chewing time, DM/bolus, NDF/bolus, NFC/bolus, boluses/day, time/bolus, chews/bolus was observed for two days, during the last week of the experimental period (Fischer, 1996). Observations were made during three periods of two hours, during the two observational days. Observations were made from 10:00 a.m. to 12:00 p.m., from 02:00 p.m. to 04:00 p.m. and from 06:00 p.m. to 08:00 p.m., as described by Burger et al. (2000). The collection data was performed with the use of digital timers handled by four observers, on the pre-determined periods, to identify the time spent on each activity.

Experimental design and statistical analysis

A completely randomized experimental design was used, with four treatments and four replications. Data analysis consisted of Pearson's linear correlation coefficient between behavior variables and DM, NDF and ADF intake. The coefficients found had their significance obtained through the Student's t-test, at 5% probability, using the software package Statistical Analysis for Genetic Epidemiology - SAEG (UFV, 2000).

RESULTS AND DISCUSSION

Data of the values of intake and ingestive behaviour on which these correlations were based are on the paper of Silva et al. (2005).

There was no correlation between feeding and dry matter intake (DMI) ($P > 0.05$). As for NDF and NFC variables, there was moderate and positive correlation with the feeding time ($P < 0.05$; Table 3).

By evaluating the ingestive behavior of cattle finished in feedlot systems and fed different levels of concentrate, Missio et al. (2010) have noted that the results concerning the time allocated to food consumption was highly correlated with the level of neutral detergent fiber; the correlation was 0.70 ($P < 0.01$).

Information of the correlations regarding behavioral and intake variables is of paramount importance to build equations that are predictive of animal's consumption, which represents the key variable on any nutritional trial. After establishing variables that could be potentially used in predictive models, it may be possible to reduce the use of invasive techniques that compromise the animal's responses.

There was a high correlation between that referring to rumination and NDF intake ($P < 0.05$) and a moderate positive correlation with rumination and DM, and NFC intake ($P < 0.05$). There was a strong negative correlation with resting period and NDF intake ($P < 0.05$), and a moderate positive correlation between the variables referring to resting and intakes of DM and NFC ($P < 0.05$). The NDF intake is closely related to the variables involving rumination activities; hence, the negative correlation of this variable with resting time was already expected. Dias et al. (2014), found a negative correlation ($P < 0.05$) between NDF for meals in grams and average daily gain. Because the NDF content of the feeds is directly related to intake, and the latter with performance, as the NDF intake is elevated, the intake by the animals might be limited by the filling effect, which may impair performance.

The feed efficiency of DM was ($P < 0.05$) moderate negative correlated (Table 4) with NDF intake (i.e. it indicates an inverse relationship between these parameters). The feeding efficiency of NDF was positively correlated with all intake variables tested, with the highest correlation with DMI. There was no correlation for the feeding efficiency of non-fiber carbohydrates between the consumption variables.

There was a moderate negative correlation between rumination efficiency of DM and NFC ($P < 0.05$) with NDF intake. Likewise, these variables are not correlated ($P > 0.05$) with the consumption of DM and NFC (Table 2). In this study, the inclusion of cassava bagasse has improved the efficiency of DM rumination, which explains the low correlation with NDF intake, considering that the inclusion of cassava bagasse led to decreased NDF levels.

Unlike the results observed for the above mentioned variable, the efficiency of NDF rumination had a positive correlation with intake of DM and NFC.

The efficiency of rumination is important to control the use of low digestibility food, since when animals are fed high digestibility feed they ruminate larger amounts of food during the common 8 or 9 hours of rumination, thus allowing a greater intake of food and better growth performance (Welch, 1982).

The total chewing time (TCT) had a moderate positive correlation between intake of DM and NFC (Table 5). The NDF consumption was highly correlated with TCT. This result was expected, considering that the stimulus of chewing activities is promoted by the dietary fiber content.

There was a negative correlation ($P > 0.05$) between DM per bolus and intake of DM, NDF and NFC (Table 5). On the contrary, the variable referring to NDF per bolus had a high positive correlation with NDF intake and a moderate positive correlation with NFC intake.

Non-fiber carbohydrate per bolus was not correlated ($P > 0.05$) with intake of DM and NFC, but had a negative correlation ($P < 0.05$) between NDF intake.

The number of boluses per day was highly correlated ($P < 0.05$) between the intake of DM, NDF and NFC. The high correlation between the evaluated variables presents a strong association between the behavioral aspects related to the ingestion and consumption of feed, which could make possible to predict the intake levels through the use of statistical models. Thus, it would not necessarily require the use of invasive methods, which could lead to misleading results or even influence intake levels. Santana Jr et al. (2013), found a positive correlation to the number of boluses and body weight. According to the author this connection between body weight and rumination process variables is associated with the volumetric capacity of the rumen, since it is known that the development of the rumen occurs with increasing age of the animal, and that it is connected to lifting of body weight.

There was a high correlation between time per bolus and NDF intake ($P < 0.05$), whereas the observed correlation between NFC intake was positive moderate.

Chewing per bolus was highly correlated ($P < 0.05$) between intake of NDF and NFC, and a moderate correlation between DMI.

Ruminants can reduce the length of daily time spent on chewing activity by improving the efficiency to reduce particulate matter (Deswysen et al., 1987); by decreasing the proportion of mandibular movements in relation to the total number of movements (Deswysen & Ehrlein, 1981); by reducing the intervals between

ruminal boluses (Gordon, 1965);by increasing the rate of mandibular movements (Bae et al., 1981); or through a combination of all these actions.

CONCLUSION

The variables referring to time of feeding, rumination and boluses per day were observed to be highly correlated between the consumption variables, and therefore presents potential for developing predictive equations.

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Table 1 - Proportion of ingredients in concentrates (%) on the natural basis

Ingredient	Level of cassava bagasse			
	5	10	15	20
Corn meal	57.0	56.2	55.5	54.7
Soybean meal	36.9	37.7	38.4	39.2
Urea	2.0	2.0	2.0	2.0
Ammonium sulfate	0.3	0.3	0.3	0.3
Calcitic limestone	1.7	1.7	1.7	1.7
Dicalcium phosphate	1.2	1.2	1.1	1.1
Mineral salt ¹	1.0	1.0	1.0	1.0

¹Composition: 18.5% of calcium, 9% of phosphorus, 0.4% of magnesium, 1% of sulfur, 11.7% of sodium, 30 ppm of selenium, 1500 ppm of copper; 4000 ppm of zinc; 1200 ppm of manganese; 150 ppm of iodine, 150 ppm of cobalt

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Table 2 – Chemical-bromatological composition (% DM) of experimental diets and cassava bagasse

Item (%)	Level of cassava bagasse				Cassava bagasse
	5	10	15	20	
DM ¹	34.92	38.55	41.82	43.36	87.50
CP ²	13.55	13.88	13.61	14.07	1.91
NDF ³	48.97	42.94	38.70	36.79	12.02
ADF ⁴	27.49	23.59	20.86	19.91	6.73
EE ⁵	3.33	3.09	3.08	2.85	0.60
Ashes	7.67	7.04	6.18	6.33	1.62
OM ⁶	92.33	92.96	93.82	93.67	98.38
NFC ⁷	26.49	33.05	38.42	39.95	83.85

¹Dry matter, ²crude protein, ³neutral detergent fiber, ⁴acid detergent fiber, ⁵ethereal extract, ⁶organic matter, ⁷non-fiber carbohydrate

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Table 3 - Linear correlations between ingestive behavior and intake by $\frac{3}{4}$ Holstein x $\frac{1}{4}$ Zebu heifer in feedlot

Behavior variables	Intake variables					
	DM Intake		NDF Intake		NFC intake	
	r	P	r	P	r	P
Feeding	-	-	0.81	0.0001	0.53	0.0159
Rumination	0.56	0.0128	0.97	0.0000	0.68	0.0018
Resting	-0.51	0.0229	-0.94	0.0000	-0.65	0.0032

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Table 4- Linear correlations between feeding (Effe) and rumination (Efru) efficiencies of dry matter (DM), neutral detergent fiber (NDF) and non-fiber carbohydrates (NFC) intake by $\frac{3}{4}$ Holstein x $\frac{1}{4}$ Zebu heifer in feedlot

Behavior variables	Intake variables					
	DM Intake		NDF Intake		NFC intake	
	r	P	r	P	r	P
EffeDM	-	-	-0.47	0.0340	-	-
EffeNDF	0.73	0.0006	0.59	0.0085	0.67	0.0023
EffeNFC	-	-	-	-	-	-
EfruDM	-	-	-0.73	0.0006	-	-
EfruNDF	0.86	0.0000	-	-	0.76	0.0003
EfruNFC	-	-	-0.67	0.0022	-	-

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Table 5 - Linear correlations between aspects of rumination and intake by $\frac{3}{4}$ Holstein x $\frac{1}{4}$ Zebu heifer in feedlot

Behavior variables	Intake Variables					
	DM Intake		NDF Intake		NFC intake	
	r	P	r	P	r	P
TCT ¹	0.50	0.0230	0.94	0.0000	0.65	0.0033
DM/bolus ²	-0.47	0.0348	-0.92	0.0000	-0.57	0.0100
NDF/bolus ³	-	-	0.88	0.0000	0.50	0.0231
NFC/bolus ⁴	-	-	-0.73	0.0005	-	-
Boluses/day	0.92	0.0000	0.93	0.0000	0.95	0.0000
Time/bolus	-	-	0.86	0.0000	0.57	0.0130
Chews/bolus ¹	0.68	0.0018	0.94	0.0000	0.81	0.0001

¹Total chewing time, ²dry matter/bolus, ³neutral detergent fiber/bolus, ⁴non-fiber carbohydrates/bolus

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