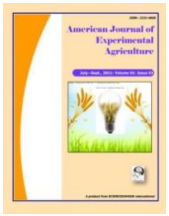

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Correlation between Intake and Ingestive Behaviour of Confined Holstein-Zebu Crossbred Heifers

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Authors' contributions

This work was carried out in collaboration between all authors. Author RRS designed the study, wrote the protocol and wrote the first draft of the manuscript. Authors ACO, GGPC, FFS, FBLM, VVSA, AAP, and APGS reviewed the experimental design and all drafts of the manuscript and managed the analyses of the study and performed the statistical analysis. Authors LBOR and RMP performed the translation and correction of English. All authors read and approved the final manuscript.

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ABSTRACT

The aim of the study was to evaluate the correlation between variables referring to feed intake and behaviour of confined Holstein-Zebu crossbred heifers. The experiment was conducted at the dairy

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unit of the Southwest Bahia State University, campus Itapetinga, Brazil. Sixteen ¾ Holstein x ¼ 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.

1. INTRODUCTION

The animals are able to express their feeding behavior through metabolic alterations caused by the amount of a certain nutrient intake, however According to [1] the correlation between the intake of nutrients, performance, and animal behavior can serve as extremely relevência for the understanding of metabolic and nutritional aspects of beef production tool, eliminating the need for invasive tests that in many cases not meet the requirements of well-being in force, in which the animals are subjected. 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.

The studying the ingestive behavior is a highly important tool in the evaluation of diets, because through it is possible to acquire knowledge of the possible relationships existing between the plant-supplements-animal interface, allowing us to adjust the feeding management of animals to obtain better productive performance [2].

Studies on the ingestive behaviour of ruminants have increased over the last years [3,4,5], as researchers need to distinguish and recognize the behavioural 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 behavioural observation. [6], report that the study of ingestive behavior of cattle is an important tool for the development of strategies which support research enabling adjustment of feeding and management techniques to improve the growth performance of the animals.
Despite that not all intake variables are directly related to ingestive behaviour, 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 behaviour of animals and consequently reflect on their consumption and performance.

The quality of forages, especially the fiber content, is one of the factors directly related to the stimulation of chewing, saliva production, rumen motility and rumen maintenance may interfere with feeding behavior [7], where as the consumption of concentrates and finely ground or pelleted hay is associated with reduced rumination time [8]. The objective of this study was to evaluate the correlation between the variables referring to behaviour and food intake by confined Holstein-Zebu crossbred heifers, which will help the development of models.

2. MATERIALS AND METHODS

2.1 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 ¾ Holstein x ¼ 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 m^2. 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 isonitrogenous. 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 [9], 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 fibre (NDF) and non-fibre carbohydrates (NFC).

2.2 Ingestive Behaviour

Feeding, rumination and resting observations were made for 48 consecutive hours, with intervals of five minutes [10]. 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 [11]. 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 [12]. 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.

2.3 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 behaviour 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 - [13].

3. RESULTS AND DISCUSSION

Data of values of intake and ingestive behaviour on which these correlations were based on the report by [14]. 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 behaviour of cattle finished in feedlot systems and fed different levels of concentrate, [15]. Noted that the results concerning the time allocated to food consumption was highly correlated with the level of neutral detergent fibre; the correlation was 0.70 ($P<0.01$).

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

[1]*Composition: 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*

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

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

Information on the correlations regarding behavioural 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 rumination time 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 was closely related to the variables involving rumination activities; hence, the negative correlation of this variable with resting time was already expected. [16], 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 significantly (P<0.05) moderately negatively 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-fibre 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 were 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 digestible food, since when Animals are fed high digestible feed they ruminate larger amounts of food during the normal 8 or 9 hours of rumination, thus allowing a greater intake of food and better growth performance [17].

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 was promoted by the dietary fibre 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-fibre 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 behavioural 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. [18], 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.

[16], found a positive correlation between rumination and the average daily weight gain of the animals, the greater rumination leads to better utilization of ingested food, which consequently allows increase in food intake improving their performance.

Table 3. Linear correlations between ingestive behavior and intake by ¾ holsteinx ¼ 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

Table 4. Linear correlations between feeding (Effe) and rumination (Efru) (g/h) efficiencies of dry matter (DM), neutral detergent fiber (NDF) and non-fiber carbohydrates (NFC) intake by ¾ holsteinx ¼ 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	-	-

Table 5. Linear correlations between aspects of rumination and intake by ¾ holstein x ¼ 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

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

[19], reported that the efficiency of rumination tends to decrease due to the reduction in the rates of fiber in diets with a higher amount of fiber, yet [14] state that depends on the magnitude of variation of the dietary fiber and the rate of its components.

A moderate correlation to the number of ingested ruminated bolus may be due to a greater time spent cake during rumination, or because the composition of the diet with high percentages of concentrated which have a lower amount of NDF causing the animal decrease number of chews per bolus and, consequently, lower rumination by number of cakes per day [16].

4. CONCLUSION

Based on the results obtained in this study enabled us to verify high correlation between time spent eating, ruminating and daily cakes with consumption variable, showing that there is potential for the development of prediction equations to allow for better utilization and consequently better animal performance .

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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