

1 UNDER PEER REVIEW

4 Original Research Article

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

8 ABSTRACT

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

18 KEYWORDS: ethology, intake, nutrition, rest, rumination

20 INTRODUCTION

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

31 Studies on the ingestive behavior of ruminants have increased over the last years (Missio et al.,
32 2010; Silva et al., 2010; Pereira et al., 2009), as researchers need to distinguish and recognize the
33 behavioral aspects, which are directly related to the need for understanding the variation from diet
34 responses. These variables are not well understood when individually evaluated, thus, they require
35 behavioral observation. It is necessary to improve methods that evaluate the consumption
36 influence, so that both variables (animal and diet) can be defined and strategies developed to

37 optimize the production process (Detmann et al. 2001). Despite that not all intake variables are
38 directly related to ingestive behavior, identifying those that can be highly correlated to it might
39 generate subsidies for the establishment of models that can properly estimate consumption,
40 without the need of invasive techniques. These techniques would alter the feeding behavior of
41 animals and consequently reflect on their consumption and performance.

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

48 MATERIALS AND METHODS

49 Animal management and sampling

50 The experiment was conducted at the Cattle Farming Unit of Southwest Bahia State University from
51 November 2004 to February 2005. Sixteen ¾ Holstein x ¼ Zebu heifers with average age of 12
52 months old and initial weight of 150 kg were randomly distributed into four treatments and four
53 repetitions. The animals were kept in individual concrete-floored pens of 2.5 m².The experimental
54 period lasted 70 days, with 14 days for adaptation. All observations were made on the last week of
55 the experimental period. The animals were fed a diet consisting of forage to concentrate ratio of a
56 60:40, based on dry matter content and diets were fed ad libitum. Elephant grass silage was
57 replaced by 5, 10, 15 or 20% cassava bagasse. These levels corresponded to the four treatments,
58 which were formulated to be isonitrogenous. The concentrate contained corn, soybean meal, urea +
59 ammonium sulfate and mineral mix (Table 1).

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

62 Food was provided twice a day at 7:00 a.m. and 04:00 p.m. and water was always available. The
63 amount of food provided was adjusted according to the previous day's consumption, ensuring 5 to
64 10% leftovers. The amount of food provided and leftovers were daily removed and weighed
65 individually.

66 Concentrates were sampled on a weekly basis. Silage and leftovers were sampled daily and pooled
67 weekly. All samples (silage, concentrates and leftovers) were pre-dried in a forced ventilated oven at
68 65°C and ground in a 1 mm mesh sieve for subsequent laboratory analysis of dry matter (DM),
69 neutral detergent fiber(NDF) and non-fiber carbohydrates (NFC).

70 Ingestive behavior

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

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75 Total chewing time, DM/bolus, NDF/bolus, NFC/bolus, boluses/day, time/bolus, chews/bolus was
76 observed for two days, during the last week of the experimental period (Fischer, 1996). Observations
77 were made during three periods of two hours, during the two observational days. Observations were
78 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
79 p.m., as described by Burger et al. (2000). The collection data was performed with the use of digital
80 timers handled by four observers, on the pre-determined periods, to identify the time spent on
81 each activity.

82 Experimental design and statistical analysis

83 A completely randomized experimental design was used, with four treatments and four replications.

84 Data analysis consisted of Pearson's linear correlation coefficient between behavior variables and
85 DM, NDF and ADF intake. The coefficients found had their significance obtained through the
86 Student's t-test, at 5% probability, using the software package Statistical Analysis for Genetic
87 Epidemiology - SAEG (UFV, 2000).

88 RESULTS AND DISCUSSION

89 Data of the values of intake and ingestive behaviour on which these correlations were based are on
90 the report by Silva et al. (2005). There was no correlation between feeding and dry matter
91 intake (DMI) ($P > 0.05$). As for NDF and NFC variables, there was moderate and positive correlation
92 with the feeding time ($P < 0.05$) (Table 3).

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

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

102 There was a high correlation between that referring to rumination time and NDF intake ($P < 0.05$)
103 and a moderate positive correlation with rumination and DM, and NFC intake ($P < 0.05$). There was a
104 strong negative correlation with resting period and NDF intake ($P < 0.05$), and a moderate positive
105 correlation between the variables referring to resting and intakes of DM and NFC ($P < 0.05$). The NDF
106 intake is was closely related to the variables involving rumination activities; hence, the negative
107 correlation of this variable with resting time was already expected. Dias et al. (2014), found a
108 negative correlation ($P < 0.05$) between NDF for meals in grams and average daily gain. Because the
109 NDF content of the feeds is directly related to intake, and the latter with performance, as the NDF
110 intake is elevated, the intake by the animals might be limited by the filling effect, which may impair
111 performance. The feed efficiency of DM was significantly ($P < 0.05$) moderately negatively correlated
112 (Table 4) with NDF intake (i.e. it indicates an inverse relationship between these parameters). The
113 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 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 ~~are~~ 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 common normal 8 or 9 hours of rumination, thus allowing a greater intake of food intake 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~~ was promoted by the dietary fiber 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-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.

153 CONCLUSION

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

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