Intake and feeding behaviour of Morada Nova lambs fed different energy levels

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Abstract

The effects of metabolizable energy levels were evaluated on nutrient intake and ingestive behaviour in Morada Nova lambs. Forty Morada Nova lambs were used with an initial weight of 12.2±2.05 kg. Five treatments were defined according to the metabolizable energy levels (0.96, 1.28, 1.72, 2.18 and 2.62 Mcal/kg DM). The experimental model was a randomized block design. Linear effect (P<0.0001) of ME levels was determined for dry matter intake (DMI), organic matter (OM), crude protein (CP), total carbohydrates (TC), non-fibrous carbohydrates (NFC) and total digestible nutrients (TDN) in g/day. Quadratic effect was determined for NDF (P<0.017) and carbohydrates (NFC) and total digestible nutrients (TDN) in g/day. Quadratic effect was determined for NDF (P<0.017) and carbohydrates (NFC) and total digestible nutrients (TDN) in g/day.

Introduction

The importance of small ruminants in undeveloped countries as a source of animal protein and income is increasing. In tropical regions such as Brazil, production systems are based on pastures, which represent the lowest cost feed resource for ruminant feeding (Duarte et al., 2011). Consequently, animal growth is slowed, mainly due to distribution and seasonal variation in quantity and quality of forage in the tropical environments. Therefore, the use of feedlot animals has been increased in Brazil because, among other reasons, the rate of weight gain is greater with concentrate than with roughage-based diets, which reduces feeding time and consequently reduces the cost of interest on the capital invested in animals.

However, in all environments feed characteristics influence animals’ motivation to eat, dietary choices and, ultimately, nutrient intake (Baumont et al., 2000; Haddad, 2005; Luo et al., 2000; Pimentel et al., 2011). In all production systems, it is generally economically sensible to maximize the proportion of forage in the diet to minimize feeding costs. When fed indoors, animals are usually fed twice a day. Sixty to 80% of daily intake is eaten during two main meals following distributions. The main characteristics of feeding behaviour are described in terms of the satiation process and motivation to eat (Provenza, 1995).

The eating behaviour of ruminants, such as feed intake, rumination time and number of chews, varies by feed type and physical characteristics and has an important effect on the digestive physiology of the ruminant. Moreover, it is used as an indicator of the physical and chemical characteristics of roughage (Lee et al., 2004b; Lee et al., 2008). In particular, the physical shape and feeding ration of roughage affects the eating and ruminating time (Gill et al., 1969; Castle et al., 1979) and considerably changes the buffering capacity in the rumen by affecting the secretion of saliva (Barley, 1976).

The Morada Nova breed has its origins in Northeastern Brazil. But there is still little scientific information about this breed and most studies have been based on breed crossing to produce heavier animals for meat (McManus et al., 2010). Feed cost represents the largest portion of the production cost. Therefore, differences among small ruminants and digestive efficiency are very important criteria for the selection of the most appropriate animal to be kept in any particular circumstance. The objective of this work was to study the differences in nutrient intake and feeding behaviour of Morada Nova lambs fed with different energy levels.

Materials and methods

Experiment site

The experiment was carried out at the Animal Laboratory of the Department of Animal Science of the Universidade Federal do Ceará (UFC) in Fortaleza-CE, Brazil. Humane animal care and handling procedures were followed according to the University’s animal care committee.

Animals, housing and feeding

Forty Morada Nova non-castrated male lambs, with average initial body weight (BW) of 12.20±2.05 kg at approximately 60 days old were used. First, animals were identified, wormed and placed in individual stalls with feeding troughs for food and water. The lambs were allocated randomly to five treatments that consisted of increasing levels of metabolizable energy (0.96; 1.28; 1.72; 2.18 and 2.62 Mcal/kg DM) obtained from different roughage:concentrate ratios (95:5, 80:20, 60:40, 40:60 and 20:80). Lambs were subjected to an adaptation period of 20 days and after that were kept in confinement until they reached an average 25
kg of body weight, after which the group was slaughtered. On this occasion, a random 2 animals of the control group (0.96 Mcal/kg DM) were also slaughtered. This procedure was carried out for each group until all the animals had been slaughtered. Average days in confinement to obtain the predetermined weight were 98, 109, 146 and 174 days at levels of 2.62, 2.18, 1.72 and 1.28 Mcal/kg DM, respectively.

The experimental model was a randomized block design with eight replications. The experimental diets were formulated according to the National Research Council (2007) and were offered as a total mixed ration. Animals had free access to water throughout the trial. Diets were formulated to be isonitrogenous with 16% CP (DM basis) to a 200 g daily gain, except for the ratio 95:5, formulated to meet the requirements for maintenance with 9% CP. Diets were composed of Tifton 85 hay as roughage and concentrates based on corn grain, soybean meal, urea, sodium chloride, calcium carbonate, dicalcium phosphate and mineral premix (Tables 1 and 2).

**Particle size of the experimental feed**

Particle sizes of the experimental feed were measured using a Penn State particle separator (PSPS), according to the method used by Kononoff and Heinrichs (2003). Samples of the experimental diets (approximately 100 g) were taken to determine particle sizes through manual agitation in the PSPS, which consisted of three sieves (1.18, 8, and 19 mm) that could separate feed into four different types depending on the particle size. This allowed the estimation of physically effective neutral detergent fibre (peNDF) according to Mertens (1997), whereby the concentration of NDF (% DM) of feed is multiplied by the percentage of particles retained in sieves 1.18 mm. The value of the effectiveness of feed is equal to the product of this operation, according to the formula:

\[ \text{peNDF}_{1.18} = \left( \frac{\% \text{DM retained 1.18 mm}}{\% \text{NDF of diet}} \right) \times 100 \]

**Intake and chemical analysis**

Animals were fed individually ad libitum twice a day (at 08h00 and 16h00). Feed refusals were measured before the morning feeding and the amount of feed offered was adjusted to allow a 10% refusal. Daily dry matter intake (DMI) was determined by the difference between the weight of the diet offered and theorts. Every day, before the feed supply, diet and orsts of each animal were removed and weighed, and data were recorded in spreadsheets for daily control. Samples of feeds and orsts were weighed, packed and frozen each day for subsequent chemical analysis. Forage, concentrate and orsts composited samples were dried at 55°C for 72 h in a forced convection oven.

**Table 1. Chemical composition of the ingredients in g/kg DM (unless otherwise stated).**

| Ingredient          | Tifton hay | Corn meal | Soybean meal | Concentrate |
|---------------------|------------|-----------|--------------|-------------|
| DM, g/kg            | 953.6      | 891.0     | 951.8        | 967.0       |
| OM                  | 873.8      | 879.3     | 885.7        | 930.4       |
| CP                  | 78.9       | 91.4      | 546.3        | 298.6       |
| EE                  | 14.6       | 53.9      | 29.1         | 25.4        |
| Ash (g/kg)          | 79.8       | 11.7      | 66.1         | 36.6        |
| NDF                 | 754.0      | 176.6     | 154.3        | 128.7       |
| NDF (%)             | 0.44       | 0.38      | 0.56         | 0.14        |
| ADF                 | 424.7      | 82.8      | 145.4        | 96.7        |
| ADIN                | 2.66       | 5.44      | 0.38         | 0.04        |
| LIG                 | 51.2       | 8.1       | 37.3         | 9.5         |
| CEL                 | 304.4      | 24.1      | 55.3         | 35.7        |
| HEM                 | 106.8      | 93.8      | 8.9          | 32.0        |
| Urea                | 526.7      | 642.9     | 358.4        | 675.1       |
| Lignin              | 701.3      | 138.8     | 104.2        | 96.0        |
| NDF (%)             | 125.3      | 704.1     | 254.2        | 579.1       |

**Table 2. Composition of the experimental diets.**

| Ingredient          | Tifton hay | Corn meal | Soybean meal | Concentrate |
|---------------------|------------|-----------|--------------|-------------|
| Dry matter, g/kg    | 954.3      | 955.4     | 953.9        | 956.4       |
| Mineral matter, g/kg DM | 38.0    | 78.5      | 64.8         | 55.2        |
| Crude protein, g/kg DM | 89.9    | 168.2     | 159.1        | 164.4       |
| Ether extract, g/kg DM | 24.9   | 26.7      | 27.9         | 22.4        |
| Neutral fibre detergent, g/kg DM | 722.5 | 629.6     | 509.6        | 386.0       |
| peNDF, g/kg DM      | 60.07      | 48.54     | 31.20        | 16.98       |
| Acid fibre detergent, g/kg DM | 429.6 | 372.8     | 285.9        | 208.0       |
| Lignin, g/kg DM     | 48.1       | 43.7      | 37.3         | 31.8        |
| Cellulose, g/kg DM  | 283.2      | 259.8     | 197.6        | 142.8       |
| Hemicellulose, g/kg DM | 283.9  | 256.8     | 223.7        | 178.0       |
| Fibrous carbohydrates, g/kg DM | 671.1 | 581.0     | 465.1        | 397.7       |
| Total carbohydrates, g/kg DM | 817.3 | 735.7     | 674.6        | 574.8       |
| Non-fibrous carbohydrates, g/kg DM | 146.2 | 154.7     | 299.5        | 416.3       |
| Total digestible nutrients, g/kg DM | 280.1 | 344.6     | 453.9        | 583.9       |
| TDN/CP              | 3.12       | 2.04      | 2.85         | 3.61        |

**Chemical components**

| Ingredients          | Tifton hay | Corn meal | Soybean meal | Concentrate |
|---------------------|------------|-----------|--------------|-------------|
| Dry matter, g/kg    | 954.3      | 955.4     | 953.9        | 956.4       |
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*Centesimal concentration in relation to the concentrated portion of the diets. *Composition: Ca 7.7%; P 3%; Fe 16.500 ppm; Mn 9750 ppm; Zn 35.000 ppm; I 1000 ppm; Se 225 ppm; Co 1000 ppm. *Physically effective neutral detergent fibre.
air oven, then ground in a knife mill with a 1 mm screen (Wiley mill, Arthur H. Thomas, Philadelphia, PA, USA). The samples were analyzed for dry matter contents (DM) (AOAC 1990; method no. 930.15), ash (AOAC 1990; method no. 924.05), crude protein (CP) (AOAC 1990; method no. 984.13), ether extract (EE) (AOAC 1990; method no. 920.39) and acid detergent fibre (ADF) (Van Soest et al., 1991). To analyze the neutral detergent fibre (NDF), the samples were treated with thermo-stable alpha amylase without the use of sodium sulfite, corrected for residual ash (Mertens, 2002) and for residual nitrogenous compounds (Licitra et al., 1996).

The total carbohydrate content (TC) was calculated using the expression:

\[ TC(\%) = 100 - (\%CP + \%EE + \%ash) \]

according to Sniffen et al. (1992). The non-fibrous carbohydrates (NFC) were calculated from the equation adapted from Weiss (1999), where:

\[ NFC(\%) = 100 - (\%NDFap + \%CP + \%EE + \%ash) \]

Because of the presence of urea in concentrate constitution, the NFC was calculated from the adapted equation by Hall (2000), where:

\[ NFC = 100 - [\%CP - \%CP derived from urea + \% of the urea] + \%NDFap + \%EE + \%ash] \]

Digestibility trials were conducted to determine metabolizable energy (ME) of the diets. Indigestible acid detergent fibre (ADF) was used as a marker to estimate faecal DM excretion as described by Casali et al. (2009). Feces were collected every 15 days for three consecutive days: at 08h00 on the first day, at 12h00 on the second day and at 16h00 on the third day. Samples of feces, feeds (Tifton 85 hay and concentrate) andorts from the digestibility trial were dried at 55°C, ground to pass through a 1 mm screen (Wiley mill, Arthur H. Thomas, Philadelphia, PA, USA). The samples were analyzed for dry matter contents (DM), ash, crude protein (CP), ether extract (EE), acid detergent fibre (ADF) and acid detergent fibre corrected for ash and protein and acid detergent ether extract, respectively. The dietary DE was estimated as 4.409 Mcal/kg of TDN, and DE was converted to ME using an efficiency of 82% to convert DE to ME (NRC, 2000).

**Feeding behaviour**

To measure the digestive behaviour variables, animals were submitted to visual observation in the 95th and 96th days of the experiment. First day observations were registered at 5-min intervals for 24 h to determine the time spent eating, ruminating and idle, according to the methodology proposed by Johnson and Combs (1991). The shed was kept under artificial lighting at night throughout the experimental period.

On the second day, animals were observed during 3 periods of 2 h (08h00 to 10h00, 14h00 to 16h00, and 18h00 to 20h00). These data were used to estimate the number of chews per ruminal bolus and time spent chewing per ruminal bolus, using a chronometer. The variables of ingestive behaviour were obtained by the equations:

\[
\begin{align*}
FE &= \text{DMI}/\text{ET}; \quad FE = \text{NDFi}/\text{ET} \\
RE &= \text{DMI}/\text{RT}; \quad RE = \text{NDFi}/\text{RT} \\
\text{TCT} &= \text{ET} + \text{RT} \\
\text{Nrb} &= \text{RT}/\text{TCrbs} \\
\text{NCd} &= \text{Nrb} \times \text{NCrbs}
\end{align*}
\]

where:

\[
\begin{align*}
\text{FE} &= (\text{g DM/h, g NDF/h}) \text{ is the feeding efficiency;} \\
\text{DMI} &= (\text{g DM/day}) \text{ is the dry matter intake;} \\
\text{ET} &= (\text{h/day}) \text{ is the eating time;} \\
\text{RE} &= (\text{g DM/h, g NDF/h}) \text{ is the rumination efficiency;} \\
\text{RT} &= (\text{h/day}) \text{ is the ruminating time;} \\
\text{TCT} &= (\text{h/day}) \text{ is the total chewing time;} \\
\text{Nrb} &= (\text{no./day}) \text{ is the number of ruminal boluses;} \\
\text{TCrbs} &= (\text{sec/bolus}) \text{ is the time spent chewing ruminal bolus;} \\
\text{NCrbs} &= (\text{no./bolus}) \text{ is the number of chews per ruminal bolus;} \\
\text{NCd} &= (\text{no./day}) \text{ is the number of chews per day (Polli et al., 1996).}
\end{align*}
\]

**Statistical analysis**

The experimental design was a randomized block (initial body weight), with five treatments, according to the mathematical model:

\[
Y_{ij} = \mu + \alpha_i + \beta_j + e_{ij}
\]

where:

\[
Y_{ij} = \text{value observed in the plot that received the treatment } i \text{ in the block } j; \\
\mu = \text{general average of the population;} \\
\alpha_i = \text{effect of treatment } i = 1, 2, 3, 4, 5; \\
\beta_j = \text{effect of the block } j = 1, 2, 3, 4, 5, 6, 7, 8; \\
e_{ij} = \text{random error.}
\]

The statistical analyses were performed using PROC GLM of the SAS version 9.0 (SAS, 2003). An orthogonal partition of the sum of the square of treatments into linear, quadratic and cubic degree effects was obtained by analysis of variance. Regression equation was adjusted when 0.05 significance was observed, using PROC REG SAS (9.0).

**Results and discussion**

**Nutrient intake**

A linear effect (P<0.0001) was observed for DM, OM, CP, NFC and TDN intakes (g/day) with increased diet ME levels. Increased ME levels promoted a quadratic effect for NDF (P<0.0170) and FC (P<0.0030) intakes (g/day), with critical points (maximum response) at ME levels of 1.56 and 1.44 Mcal/kg DM, respectively. A similar pattern was also observed for FC (P<0.0001) intake, when expressed in g/kgBWs0.75 with critical points (maximum response) at ME levels of 1.79 Mcal/kg DM (Table 3).

Medeiros et al. (2007) reported linear increase in intake with values of 925, 964, 1,063 and 1,124 g/day for sheep fed diets containing 20, 40, 60 and 80% concentrate, values similar to those reported by Mahgoub et al. (2000), when three energy levels (2.4, 2.5 and 2.7 Mcal/kg DM) were assessed in Omani growing lambs’ diets. NFC intake, when expressed in g/day, showed quadratic behaviour with the ME increase in the diets, indicating the existence of an inflection point or transition between the physical and biological control. According to Mertens (1987), when the energy density of the diet is high (low NFC), in relation to requirements of the animal, intake may be limited by energy demand, not rumen fill. For diets of low energy density (high content of NFC), the intake can be limited by filling the rumen reticulum.

The increase in particle size in the experimental diets with lower ME levels may also have influenced the filling effect and, consequently, the reduction of DM intake. Similarly, Kato et al. (1989) and Jeon et al. (2001) observed that the small particle size of the feed induced an increased dry matter intake.

Low-quality tropical forages are deficient not only in nutrients for animal performance, but also in substrates for microbial metabolism, mainly nitrogenous compounds (Detmann et al., 2009). Thus, inclusion of protein and/or energy sources in diets would be beneficial to the rumen environment and would increase the microbial growth on the fibrous carbohydrates (Costa et al., 2008).
Increase in intake could be a reflection of increases in the digestibility of the fibrous compounds (Lazzarini et al., 2009) which exert a high rumen fill effect. Increases in the voluntary low-quality forage intake as a result of protein sources is frequently associated with higher forage passage and digestion rates, which accelerate the removal of the indigestible fibre compounds from the rumen, resulting in a higher rumen turnover (Paulino et al., 2008). Particle size of diets may also influence intake. According to Poppi et al. (1985), the particle size of 1.18 mm is that which determines whether a particle has a rapid (<1.18 mm) or slow (> 1.18 mm) passage by the rumen, this value being valid for both sheep and cattle. Thus, the larger particle size in diets with high levels of ME (Table 4) allowed rumens to escape slowly and a higher filling effect.

Thus, if daily intake is the primary goal, theories related to the regulation of long-term consumption are the most suitable as a starting point for derivation of the equations. Therefore, the optimum content of NDF in the diet should not be fixed but should vary depending on the net energy requirement of the animal. The diet (0.96 Mcal/kg DM) containing high NDF content (722.5 g/kg DM) promoted low total DMI due to restrictions caused by the filling of the animals’ rumen-reticulum. On the other hand, the diet containing a high level of energy (2.62 Mcal/kg DM) and low fibre (267.4 g/kg DM) also resulted in lower total DM intake, indicating that animal energy requirements have been reached at lower levels of consumption. Satiety as the physiological factor limiting intake may be related to diets with high caloric density (high amount of concentrate) and, in this case, animal requirements control intake.

**Ingestive behaviour**

Eating time and ruminating time (h/day) decreased linearly (P<0.0001) with the energy levels of the experimental diets (Table 5). A linear effect was observed for ruminating efficiency (g DM/h) at the levels of ME (P<0.0001). When expressed in g NDF/h, feeding efficiency had a significant effect (P<0.0016), meanwhile rumination efficiency had no significant effect for the diet ME levels (Table 4). Kim et al. (1994) reported that the shorter the length of the feed, the higher the feeding efficiency. This was also observed by Jeon et al. (1997) who reported that feeding efficiency was higher with roughage of a smaller particle size. The total chewing time (min/day) was influenced by the ME level of experimental diets,

### Table 3. Intake of diet constituents by sheep fed with different levels of metabolizable energy.

| ME level in diet, Mcal/kg DM | SEM | L | Q | C |
|-----------------------------|-----|---|---|---|
| 0.96                        | 1.28| 2.18| 2.62|
| DM°, g/day                 | 370.38| 467.99| 527.05| 687.75| 628.86| 26.45| <0.0001| 0.0861| 0.2291|
| OM°, g/day                 | 310.84| 410.05| 487.86| 646.20| 583.85| 26.18| <0.0001| 0.0361| 0.1654|
| CP°, g/day                 | 32.05| 80.81| 89.79| 115.49| 119.01| 6.50| <0.0001| 0.0191| 0.3257|
| NDF°, g/day                | 237.03| 278.87| 265.89| 238.72| 187.99| 10.69| 0.7531| 0.0630| 0.0612|
| TC°, g/day                 | 281.23| 330.32| 400.75| 510.82| 455.79| 18.98| <0.0001| 0.0564| 0.1182|
| FC°°, g/kg BW^0.75         | 59.12| 51.64| 59.01| 75.91| 68.91| 2.53| <0.0001| 0.0351| 0.0379|
| OM°°, g/kg BW^0.75         | 45.43| 66.50| 54.63| 71.33| 65.09| 2.45| <0.0001| 0.0345| 0.0298|
| NDF°°°, g/kg BW^0.75       | 36.69| 31.50| 28.91| 26.03| 17.71| 1.55| <0.0001| 0.0380| 0.2320|

| PSD% MS retained | Tifton 85 hay | Concentrate | ME level in diet, Mcal/kg DM on sieves | SEM | L | Q | C |
|------------------|---------------|-------------|----------------------------------------|-----|---|---|---|
| 0.96             | 1.28          | 2.18        | 2.62                                   |     |   |   |   |

Above 19.0 mm

| PSD% MS retained | Tifton 85 hay | Concentrate | ME level in diet, Mcal/kg DM on sieves | SEM | L | Q | C |
|------------------|---------------|-------------|----------------------------------------|-----|---|---|---|
| 0.96             | 1.28          | 2.18        | 2.62                                   |     |   |   |   |

| ME, metabolizable energy, L, linear degree; Q, quadratic degree; C, cubic degree; DM, dry matter; OM, organic matter; CP, crude protein; NDF, neutral detergent fibre; TC, total carbohydrates; FC, fibrous carbohydrates; NFC, non-fibrous carbohydrates; TDN, total digestible nutrients; \( R^2 = 0.97 \); § § § \( R^2 = 0.85 \); \( R^2 = 31.946 \); ## \( R^2 = 5.361+3.936X \) (R=0.85).

### Table 4. Particle size distribution in percentage of feeds and diets.

| PSD% MS retained | Tifton 85 hay | Concentrate | ME level in diet, Mcal/kg DM on sieves | SEM | L | Q | C |
|------------------|---------------|-------------|----------------------------------------|-----|---|---|---|
| 0.96             | 1.28          | 2.18        | 2.62                                   |     |   |   |   |

| PSD% MS retained | Tifton 85 hay | Concentrate | ME level in diet, Mcal/kg DM on sieves | SEM | L | Q | C |
|------------------|---------------|-------------|----------------------------------------|-----|---|---|---|
| 0.96             | 1.28          | 2.18        | 2.62                                   |     |   |   |   |

### Table 5. Ingestive behaviour of Morada Nova lambs fed rations with different metabolizable energy levels.

| Items | ME level in diet, Mcal/kg DM | SEM | L | Q | C |
|-------|-------------------------------|-----|---|---|---|
| 0.96  | 1.28                         | 2.18| 2.62|     |

| Items | ME level in diet, Mcal/kg DM | SEM | L | Q | C |
|-------|-------------------------------|-----|---|---|---|
| 0.96  | 1.28                         | 2.18| 2.62|     |

| Items | ME level in diet, Mcal/kg DM | SEM | L | Q | C |
|-------|-------------------------------|-----|---|---|---|
| 0.96  | 1.28                         | 2.18| 2.62|     |

| Items | ME level in diet, Mcal/kg DM | SEM | L | Q | C |
|-------|-------------------------------|-----|---|---|---|
| 0.96  | 1.28                         | 2.18| 2.62|     |
with a decreasing linear effect (P<0.0001). According to Dulphy et al. (1980), when the cell wall constituents of the diet decreases, increasing the starch content, the total chewing time decreases, a fact detected by the linear decrease observed in the data obtained in this study (Table 4). Turino (2003) observed that diets with higher NDF and physically effective neutral detergent fibre (peNDF) promote an increase in chewing activity in sheep.

The number of ruminal boluses, number of chews per day and chews per ruminal bolus were not affected by ME. However, time spent chewing by ruminal bolus was influenced by ME (P<0.0014) by ME in the diets (Table 6). Lee et al. (2004a) and Jeon et al. (1997) reported that the shorter the cutting length (particle size) of the roughage, the lower the number of boluses.

The values of peNDF increased with increasing fibre in the diets (Table 2), which may be indicative of longer rumination and chewing times since the concept of peNDF is related to the physical characteristics of fibre to stimulate chewing activity, because of a high correlation between time spent chewing and fibre effectiveness (Mertens, 1997). Beauchemin and Yang (2005) reported that by decreasing the peNDF content of diets, the number of chews per day during intake was linearly reduced and tended to reduce the number of chews during rumination. Consequently, total chewing activity was reduced. The authors reported that eating time (min/day) and rumination time (min/day) were linearly affected by diet peNDF, as well as the total chewing time (min/day).

Figure 1 shows the distribution of consumption and ruminating activities in four periods of the day: (1) 06h00 to 12h00; (2) 12h00 to 18h00; (3) 18h00 to 24h00; and (4) 24h00 to 06h00. The sum of periods 1 and 2 corresponded to the longer time spent on consumption (82.21% of total consumption), so the consumption was concentrated during the day. These observations were also registered by Pereira et al. (2009), Dado and Allen (1995), and Macedo et al. (2007), who obtained an average of 57% of time spent feeding adding the periods 1 and 2. Dado and Allen (1995) reported that DMI is increased after feeding, when feed is still fresh. According to Forbes (1995), as ruminants are diurnal animals, their feeding activity is more frequent during the day than at night; however, this can vary. Rumination occurred mainly at night, usually the time when air temperature is milder. Rumination prevailed between periods 3 and 4 (Figure 1). The daily pattern of ruminating activity was high after 10 h of daily feed supply (period 3) and remained active during the sub-

Figure 1. Distribution of consumption and ruminating activities in four periods (06h00 to 12h00, 12h00 to 18h00, 18h00 to 24h00 and 24h00 to 06h00) of the day.

### Table 6. Ingestive behaviour of Morada Nova lambs fed rations with different metabolizable energy levels.

| ME level in diet, Mcal/kg DM | 0.96 | 1.28 | 1.72 | 2.18 | 2.62 |
|-----------------------------|------|------|------|------|------|
| SEM                         |      |      |      |      |      |
| Effect degree               | L    | Q    | C    |      |      |
| Items                       |      |      |      |      |      |
| Nrb, nº/day^                 | 643.04 | 704.73 | 689.38 | 602.38 | 616.52 |
| SEM                         | 27.74 | 27.74 | 27.74 | 27.74 | 27.74 |
| Effect degree               | 0.3498 | 0.8538 | 0.3784 |      |      |
| Ncd, nº/day^§               | 34.97650 | 38.78657 | 38.21139 | 36.32153 | 32.50752 |
| SEM                         | 1.231012 | 1.231012 | 1.231012 | 1.231012 | 1.231012 |
| Effect degree               | 0.2951 | 0.1240 | 0.6834 |      |      |
| Ncrb, nº/bol^                | 56.36 | 56.13 | 61.00 | 58.44 | 56.13 |
| SEM                         | 1.46 | 1.46 | 1.46 | 1.46 | 1.46 |
| Effect degree               | 0.9048 | 0.3167 | 0.7947 |      |      |
| Tcrb, sec/bol$               | 52.36 | 45.75 | 47.19 | 47.19 | 47.19 |
| SEM                         | 0.0004 | 0.0004 | 0.0004 | 0.0004 | 0.0004 |
| Effect degree               | 0.7959 | 0.3854 | 1.0284 |      |      |

ME, metabolizable energy; DM, dry matter; L, linear degree; Q, quadratic degree; C, cubic degree; Nrb, number of ruminal boluses; Tcrb, time spent chewing ruminal bolus; NCrb, number of chews per ruminal bolus; Ncd, number of chews per day. ^Ŷ = 634.41; §Ŷ = 36.610.70; ^= 57.61; $ = 59.298-8.342X (R^2 = 0.78).
Conclusions

The increase in ME levels in diets influences nutrient intake and feeding behaviour of Morada Nova lambs during the growing period.

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