Ingestive Behavior of Lambs Confined in Individual and Group Stalls

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ABSTRACT: The experiment was conducted to evaluate the ingestive behavior of lambs confined in individual and group stalls. We used thirty-four lambs in their growing phase, aged an average of three months, with mean initial live weight of 17.8±5.2 kg. They were allotted in a completely randomized design with 24 animals kept in individual stalls and 10 animals confined as a group. The experiment lasted for a total of 74 days, and the first 14 days were dedicated to the animals' adaption to the management, facilities and diets. The data collection period lasted 60 days, divided into three 20-d periods for the behavior evaluation. The animals were subjected to five days of visual observation during the experiment period, by the quantification of 24 h a day, with evaluations on the 15th day of each period and an interim evaluation consisting of two consecutive days on the 30th and 31st day of the experiment. The animals confined as a group consumed less ($p < 0.05$) fiber. However, the animals confined individually spent less ($p < 0.05$) time on feeding, rumination and chewing activities and longer in idleness. Therefore, the lower capacity of lambs confined in groups to select their food negatively affects their feeding behavior. (**Key Words:** Ethology, Methodology, Socialization, Sheep)

INTRODUCTION

Estimates of ingestive behavior have been reported as relevant tools in the evaluation of diets, enabling the adjustment of ruminant feed management to obtain the best productive performance (Carvalho et al., 2006).

With the recent advances in the ethology sector, the precise evaluation of behavior aspects has been widely discussed and studied by researchers throughout the country (Fischer et al., 2000; Silva et al., 2006; Carvalho et al., 2007a,b; Marques et al., 2008; Pinheiro et al., 2011a).

Sheep are extremely gregarious animals, and because of their nature they are reluctant to separate from their flock or to mix with strange animals. When suddenly introduced to new situations, they react with stress that can affect their ingestive behavior and their performance.

However, the intensification of production systems driven by market needs has caused changes to rearing environments. Transportation or moving the animals from their rearing environments to restricted environments, such as in confinement, lead the animals to change their behavior, because they begin competing for food, leadership, and often, for space. Therefore, studies involving methods to impart practicality and to increase the productivity of rearing systems are greatly relevant.

Another important item to be considered, inherent to modifications to sheep rearing environments, is related to environments planned for the collection of scientific data. These are usually designed to evaluate animals individually, consequently the animals are confined in stalls that are increasingly restricted and that can affect their behavior, hindering the natural expression of their activities.

Therefore, this study was conducted to the ingestive behavior of lambs confined to individual stalls and in groups.

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MATERIAL AND METHODS

Experimental materials and procedures

The experiment was conducted at the North Minas Gerais Federal Institute (IFNMG), Salinas-MG campus, and at the Forage Laboratory of State University of Bahia (UESB). We used Thirty four Santa Inez lambs race St. Agnes, in their growing phase, aged an average mean age of three months with a mean initial live weight of 17.8±5.2 kg, were alloted in a completely randomized design.

The diets offered to the animals were based on sugarcane and sugarcane bagasse chemically treated with urea or calcium oxide (CaO), formulated to be isonitrogenous and isoenergetic, with a roughage:concentrate of 50:50, with the base diet being formulated to meet the requirements for maintenance of animals allowing weight gain of 200 g/d, according to the requirements prescribed by National Research Council-NRC (2007).

Animals were fed daily at 8 a.m. and 4 p.m, twice daily. The experimental diets were offered as a complete mixture. Regardless of the assessed group, space was granted as an area of 1.5 m^2 per animal with water and food available *ad libitum*.

The experiment lasted for a total of 74 days, and the first 14 days were dedicated to the animals' adaption to the management, facilities and diets. The data collection period lasted 60 days, divided into three 20-d periods for the behavior evaluation.

To measure the ingestive behavior variables animals were submitted to visual observation periods of 5 d-periods during the experiment period, observations were registered at 5-min intervals of 24 h (Fischer et al., 1998), with one evaluation on the 15th day of each of the 20-d periods and one interim observation for two consecutive days, on the 30th and the 31st day, to determine the time spent eating, ruminating and idle, according to the methodology proposed by (Fischer et al., 1998).

The recording of the time spent eating, ruminating or idle was conducted by trained observers in alternate shifts, strategically placed so as not to disturb the animals, and totaled 288 observations per collection day. The recording of the time spent eating, ruminating or idle was conducted by trained observers in alternate shifts, strategically placed so as not to disturb the animals, and artificial lighting was used during nighttime observations.

On the following day, the number of cuds-chewing per bolus (NCCB/bolus) and the time spent ruminating each bolus (TRB - s/bolus) were assessed using a digital chronometer. In order to estimate the chewing and time-related averages, three ruminal boli were observed at three different periods (10 a.m. to 12-noon; 14 to 16 p.m. and 18 to 20 p.m.), according the methodology described by Burger et al. (2000). The variables referring to time and number of chews for each ruminal bolus per animal were calculated.

For the estimation of the behavioral variables, feeding and rumination variables (min/kg of DM and NDFap), feed efficiency (g DM and NDF/h), rumination efficiency (g of DM and NDFap/bolus and g DM and NDFap/h) and mean intake of dry matter (DM) and neutral detergent fiber corrected for ash and protein (NDFap) per feeding period, we considered the voluntary intake of DM and NDFap on the 15th day of each period and the 30th and 31st day of the experiment, with the remains being computed on the 16th day of each period and the 31st and 32nd day of the experiment.

The daily number of boli was obtained by dividing the total time ruminating (minutes), by the average time spent ruminating a bolus. Dry matter and NDF concentrations in each rumination bolus (g) were obtained by dividing the amount of DM and NDF consumed (g/d) in 24 h by the number of daily rumination boli. The feeding and rumination efficiency was thus obtained:

$$EALDM = CDM/TF$$

$$EALNDF = CNDF/TF$$

Where, EALDM (g DM consumed/h); EALNDF (g NDF consumed/h) = feeding efficiency; CDM (g) = daily intake of dry matter; CNDF (g) = daily intake of NDF; TF = time spent feeding every day.

$$FEDM = DMI/FT;$$

$$FENDF = NDFI/FT;$$

FEDM (DM consumed g/h); FENDF (consumed NDF g/h) = feeding efficiency; DMI (g) = daily intake of dry matter, NDFI (g) = daily intake of NDF; FT = time daily spent on feeding.

$$RUEDM = DMI/RUT$$

$$RUEFDN = NDFIap/RUT$$

Where, RUEDM (ruminated DM g/h); RUENDF (ruminated NDF g/h) = rumination efficiency and RUT (h/d) = rumination time; NDFIap = neutral detergent fibre intake corrected for ash and protein.

$$TCT = ET+RT$$

Where: TCT (min/d) = total chewing time; RT (h/d) is the ruminating time; ET (h/d) is the eating time;

These and other variables obtained in this experiment

Table 1. Means, coefficient of variation (CV), regression parameter estimates and descriptive levels of probability (p-value) associated with null hypotheses for the relationship between individual and group activities, for the intake of dry matter (DM), neutral detergent fiber corrected for ash and protein (NDFap) and feeding, rumination, chewing and idling time in lambs

Item	Activity			Linear regression			
				Interception		Coefficient of inclination	
	Individual	Group	CV (%)	Estimate	p-value[a]	Estimate	p-value[b]
Intake (g/d)							
DM	780.0	812.6	27.0	453.3979	0.0587	0.46052	0.0723
NDFap	265.5	248.2	62.5	285.9912	0.0003	-0.1422	<0.0001
Activity in min/d							
Feeding	336.0	353.4	18.4	360.1067	<0.0001	-0.0199	<0.0001
Rumination	524.4	526.4	10.5	519.7594	<0.0001	0.01262	<0.0001
Chewing	860.4	877.8	11.4	934.46889	<0.0001	-0.06587	<0.0001
Idling	579.3	562.2	17.9	600.0392	<0.0001	-0.06531	<0.0001

[a] H_0: $\beta_0 = 0$; H_a: $\beta_0 \neq 0$. [b] H_0: $\beta_1 = 1$; H_a: $\beta_1 \neq 1$.

were obtained according to the methodology described by Bürger et al. (2000).

The number of feeding, rumination and idling periods was counted by the number of activity sequences observed in the comments spreadsheet. The average daily duration of these activity periods was calculated by dividing the total duration of each activity (feeding, rumination and resting in min/d) at each interval between observations by their respective number of discrete periods. Samples of the feed provided, concentrate and it's leftovers of each animal were dried in a forced ventilation, at 60°C, and ground in a knife mill with a 1 mm screen. Analyses were carried out for determining the of dry matter (DM) was obtained according to the procedures described by Silva and Queiroz (2002).The neutral detergent fibre (NDF) corrected for ash and protein was performed according to the recommendations of Licitra et al. (1996) and Mertens (2002).

Statistical analysis

The procedures for comparing individual and group activities were carried out independently from the fixed effects of the treatments and Latin squares, by adjusting a simple linear regression model of the individual activities estimates over the group activities, while testing the regression parameter estimations under the following hypotheses:

$$H_0 : \beta_0 = 0 \qquad H_0 : \beta_1 = 1$$
$$H_a : \beta_0 \neq 0 \qquad H_a : \beta_1 \neq 1 .$$

In case of non-rejection of both null hypotheses, we concluded for the similarity between individual and group activities, i.e., absence of global bias. In the opposite situation, observing the rejection of null hypotheses, the global bias was estimated according to the equation by Detmann et al. (2005):

$$B(\%) = (\hat{\beta} - 1) \times 100$$

Where, B = global bias of estimates (%); the linear slope coefficient for the relationship between individual and group activity, assuming a null (intercept).

RESULTS AND DISCUSSION

The evaluation of DM intake estimates described on Table 1, points out the non-rejection of both null hypotheses (p>0.05), converging to the similarity between the intake of DM by animals confined individually and in a group. The opposite situation was observed for the intake of neutral detergent fiber corrected for ash and protein (NDFap) (p<0.01) and for feeding (p<0.01), rumination (p<0.01), chewing (p<0.01) and idling (p<0.01) activities (Table 1). For these, we verified rejection of the null hypotheses and the presence of global bias, indicating differences between animals confined individually and in group.

There was an indication of the presence of constant global bias for the estimates evaluated (Table 2), in which the intake of NDFap by animals in groups was underestimated in 30.65% in relation to individually

Table 2. Global bias estimates for behavior activities of lambs managed individually and in group

Item	Global bias[1]
Intake of NDFap[2] (g/d)	-30.65
Intake of NDFap[2] (g/h)	-34.86
Feeding (min/d)	1.24
Rumination (min/d)	-1.39
Chewing (min/d)	0.29
Idling (min/d)	-6.51

[1] Due to rejection of the hypothesis associated with the coefficient of inclination for the relationship between individual and group activities (Table 1), the global bias was estimated according to the proposition by Detmann et al. (2005): $B(\%) = (\hat{\beta} - 1) \times 100$

[2] Neutral detergent fiber corrected for ash and protein.

confined animals, and for feeding and chewing activities there was overestimation of 1.24 and 0.29%, respectively, whereas for rumination, these values were underestimated in 1.39% for lambs confined individually in relation to collective confinement. For idling activities, the values for individually confined animals were underestimated in 6.51% when compared to animals in group.

The similarity between the intake of DM and the higher intake of NDFap for animals reared individually can be the result of social dominance and leadership disputes between animals reared in group. The fact that the animals spent more time feeding, chewing, and less time in idleness owes probably to the intake of DM, which in spite of having no effect (p>0.05), was higher than 32.6 g/d.

When working with cattle confined in group stalls, in pairs and individually, Marques et al. (2005) verified that the rumination time of animals kept individually (116.2 min/d) and in pairs (121.3 min/d) were similar, although the animals confined in group stalls had less rumination time (100.8 min/d). However, the same authors observed that the animals kept in pairs ingested 28.1% more feed than those kept individually.

In the same study, Marques et al. (2005) found similar idling times for animals kept individually (215.1 min/d) and in group stalls (217.0 min/d), and the values for these were higher than for the ones kept in pairs (185,1 min/d). The findings by these authors confirm the results of the present work, in which the larger physical space per animal available in the two types of stalls was reported as the main cause, whereas the animals kept in collective stalls spent their time moving around the stall and in exploratory activities, or struggling for group leadership, being left with little idling time, a fact also confirmed by Prince et al. (2003).

Marques et al. (2005) also concluded in their work that animals kept individually had shorter feed ingestion time,

Table 4. Estimates of global bias for behavior activities of lambs confined individually and in group

Item	Global bias[1]
Intake of DM[2] (g/h)	-7.65
Intake of NDFap (g/h)	-34.86
Boli (No./d)	1.17
g DM[2]/bolus	-2.56
g NDFap[3]/bolus	-44.08
Bolus/s	-8.96
g DM[2]/h	2.39
g NDFap[3]/h	-32.93

[1] Due to rejection of the hypothesis associated with the coefficient of inclination for the relationship between individual and group activities (Table 3), the global bias was estimated according to the proposition by Detmann et al. (2005): $B(\%) = (\hat{\beta} - 1) \times 100$

[2] Dry matter. [3] Neutral detergent fiber corrected for ash and protein.

and animals kept in the group stall had a idling time of 26.4% daily time, with most of the remaining time being spent on leadership disputes, suggesting the need to form homogeneous lots of animals in an attempt to minimize the disputes and subsequent lesions to the animals confined in group.

With the statistical analysis presented on Table 3, we verified the non-acceptance of the null hypothesis (p<0.01) for the interception and the coefficient of inclination on feeding efficiency and rumination efficiency in lambs (Table 3), denoting the presence of constant bias. The intake of DM (g/h) related to feeding efficiency was 7.6% lower for animals evaluated individually, and the intake of NDFap (g/h) was 34.9% lower for animals confined in groups (Table 4). Although the intake of DM (g/h) was higher for animals confined in groups, the ingestion of NDFap (g/h) was lower, due to the lambs' preference for concentrate feeds and to the leadership disputes between animals in groups.

Table 3. Means, coefficient of variation (CV), regression parameter estimates and descriptive levels of probability (p-value) associated with null hypotheses for the relationship between individual and group activities, of feeding efficiency and rumination efficiency in lambs

Item	Activity			Linear regression			
				Interception		Coefficient of inclination	
	Individual	Group	CV (%)	Estimate	p-value[a]	Estimate	p-value[b]
Feeding efficiency (g/h)							
DM	152.1	159.3	37.7	150.486	0.0003	0.05807	0.0002
NDFap[1]	46.7	36.5	43.6	45.014	<0.0001	-0.18193	<0.0001
Rumination efficiency							
Boli (No./d)	716.1	756.6	16.1	739.102	<0.0001	0.02442	<0.0001
g DM/Bolus	1.1	1.2	32.4	0.970	0.0022	0.18714	0.0024
g NDFap/bolus	0.4	0.3	56.4	0.326	<0.0001	-0.09732	<0.0001
Bolus/s	45.2	42.5	14.5	41.75116	<0.0001	0.01601	<0.0001
g DM/h	92.3	101.7	27.5	107.080	<0.0001	-0.05836	<0.0001
g NDFap/h	30.2	25.4	60.1	26.100	0.0012	-0.02286	<0.0001

[a] H_0: $\beta_0 = 0$; H_a: $\beta_0 \neq 0$. [b] H_0: $\beta_1 = 1$; H_a: $\beta_1 \neq 1$. [1] Neutral detergent fiber corrected for ash and protein.

Table 5. Means, coefficient of variation (CV), regression parameter estimates and descriptive levels of probability (p-value) associated with null hypotheses for the relationship between individual and group activities, of the number of periods and time spent feeding, ruminating and idling, in lambs

Item	Activity			Linear regression			
				Interception		Coefficient of inclination	
	Individual	Group	CV (%)	Estimate	p-value[a]	Estimate	p-value[b]
Number of periods (d^{-1})							
Feeding	20.5	19	7.26	20.37904	<0.0001	-0.06936	<0.0001
Rumination	30.1	24.7	10.9	25.37004	<0.0001	-0.02225	<0.0001
Idling	40.3	35.2	8.9	37.27934	<0.0001	-0.05113	<0.0001
Time spent per period (min)							
Feeding	17.7	19.0	10.7	17.53321	<0.0001	-0.09785	<0.0001
Rumination	18.0	22.1	10.4	22.35078	<0.0001	-0.01185	<0.0001
Idling	14.4	16.3	11.8	15.24114	<0.0001	-0.07414	0.0002

[a] $H_0: \beta_0 = 0$; $H_a: \beta_0 \neq 0$. [b] $H_0: \beta_1 = 1$; $H_a: \beta_1 \neq 1$.

Among the items related to rumination efficiency, the number of boli per day, intake of DM (g/h) and grams of DM per ruminated bolus of animals evaluated in group were higher than those of animals confined individually, by 1.2%, 2.4%, 2.6%, respectively (Table 4). However, the grams of NDFap per bolus, the time spent per ruminated bolus in seconds and the grams of NDFap per hour were underestimated in 44.1; 9% and 32.9% (Table 4), in the same order of items mentioned previously, when animals confined in group are compared to animals confined individually. These results probably owe to more tranquility at feeding times enjoyed by the animals evaluated individually.

In the evaluation of estimates of number of periods, time spent per period in feeding, rumination and idling and the time spent per ruminated bolus (Table 5), both null hypotheses were rejected, and therefore, the global bias was estimated (Table 6).

An underestimation of the activities of animals kept in groups in relation to those kept individually, where a global bias was presented for the number of periods feeding, ruminating and idling, of 15.6%, 19.0% and 14.0%, respectively (Table 6). For animals kept individually, the time spent per feeding period was underestimated in 6.1%.

Table 6. Estimates of global bias for behavior activities of lambs managed individually and in group

Item	Long term bias[1]
Feeding, number of periods	-15.62
Rumination, number of periods	-18.98
Idling, number of periods	-13.99
Feeding, min/period	-6.08
Rumination, min/period	19.60
Idling	11.04

[1] Due to rejection of the hypothesis associated with the coefficient of inclination for the relationship between individual and group activities (Table 5), the global bias was estimated according to the proposition by Detmann et al. (2005): $B(\%) = (\hat{\beta} - 1) \times 100$

And for the animals kept in groups, the time spent ruminating and idling was overestimated in 19.6% and 11.0%, respectively.

According to the results, it is overwhelming that animals in individual stalls had higher (p<0.01) numbers of feeding, rumination and idling periods per day, reflecting in less (p<0.01) time spent per period (Table 6). Therefore, the most probable explanation would be the absence of social disputes among individually kept animals, providing more tranquility for these animals during feeding moments.

For animals kept in group confinement systems, feeding periods can vary from one hour, for high energy level feeds, to six or more hours for sources of lower levels of energy (Van Soest, 1994). When working with cattle confined in groups, pairs and individual stalls, Marques et al. (2005) verified that time of ingestion was longer in the treatment in pairs: 113.5 min. The authors explained that it was due to competition for food between the two animals. The animals confined in groups clocked 102.1 min in an intermediary position, and those confined individually clocked 88.60 min, probably because of the lack of competition for food and space in the trough, leading to less time required to ingest the feed.

The results obtained in the present research are in accordance with those verified by Marques et al. (2005), and the evidence mentioned by the authors was also verified, so that the number of periods of ingestion, rumination and idleness was lower for animals in groups, however, the time in minutes per period was longer for animals managed individually.

CONCLUSIONS

Based on ingestive behavior responses, we can affirm that although group confinement systems are closer to the extensive or natural model, lambs kept individually have more opportunity to feed adequately and are submitted to

less stress from social disputes, and is therefore the most recommended system.

REFERENCES

Bürger, P. J., J. C. Pereira, A. C. Queiroz, J. F. C. Silva, S. C. Valadares Filho, P. R. Cecon, and A. D. P. Casali. 2000. Ingestive behavior in Holstein calves fed diets with different concentrate levels. R. Bras. Zootec. 29:236-242.

Carvalho, G. G. P., A. J. V. Pires, R. R. Silva, B. M. A. Carvalho, H. G. O. Silva, and L. M. Carvalho. 2007a. Methodological aspects of feeding behaviour of sheep fed ammoniated elephantgrass and agro-industrial by-products. R. Bras. Zootec. 36:1105-1112.

Carvalho, G. G. P., A. J. V. Pires, R. R. Silva, C. M. Veloso, and H. G. O. Silva. 2006. Ingestive behaviour of sheep fed with ammoniated or non-ammoniated elephantgrass silage and agro industrial by-products. R. Bras. Zootec. 35:1805-1812.

Carvalho, G. G. P., A. J. V. Pires, H. G. O. Silva, C. M. Veloso, and R. R. Silva. 2007b. Methodological aspects of chewing activity of dairy goats fed cocoa meal or palm cake. R. Bras. Zootec. 36:103-110.

Detmann, E., M. F. Paulino, L. S. Cabral, S. C. Valadares Filho, P. R. Cecon, J. T. Zervoudakis, R. P. Lana, M. I. Leão, and A. J. N. Melo. 2005. Simulation and validation of digestive kinetic parameters using an *in vitro* gas production system in crossbred steers with pasture supplementation. R. Bras. Zootec. 34:2112-2122.

Fischer, V., A. G. Deswysen, L. Dèspres, P. Dutilleul, and J. F. P. Lobato. 1998. Nycterohemeral patterns of ingestive behavior of sheep. R. Bras. Zootec. 27:362-369.

Fischer, V., P. Dutilleul, A. G. Deswysen, L. Dèspres, and J. F. P. Lobato. 2000. Use of time-dependent transition probabilities for quantitative analysis of ingestive behavior of sheep. Part I. Rev. Bras. Zootec. 29:1811-1820.

Licitra, G., T. M. Hernandez, and P. J. Van Soest. 1996. Standardization of procedures for nitrogen fractionation of ruminant feed. Anim. Feed Sci. Technol. 57:347-358.

Marques, J. A., D. Maggioni, and J. J. S. Abrahao. 2005. Behavior of young bulls in confinement housed separately or in group. Arch. Latinoam. Prod. Anim. 13:97-102.

Marques, J. A., A. P. Pinto, J. J. A. Abrahão, and W. G. Nascimento. 2008. Intervals between observations for ingestive behavior evaluation of young bulls in feedlot. Semina: Ciências Agrárias, 29:955-960.

Mertens, D. R. 2002. Gravimetric determination of amylase-treated neutral detergent fiber in feeds with refluxing in beakers or crucibles: collaborative study. J. AOAC Int. 85:1217-1240.

National Research Council (NRC). 2007. Nutrient requirements of small ruminants. Washington, DC: National Academy Press. p. 362.

Pinheiro, A. A., C. M. Veloso, H. A. Santana Júnior, A. L. Rocha Neto, R. R. Silva, F. B. L. Mendes, L. N. Oliveira, S. T. Azevedo, and U. Cecato. 2011. Evaluation of the intervals and numbers of observations on the ingestive behavior of dairy heifers confined. Revista Brasileira de Saúde e Produção Animal, Salvador, 12:480-490.

Prince, E. O., T. E. Adams, and C. C. Huxoll. 2003. Aggressive behavior is reduced in bulls actively immunized against gonadotropin-releasing hormone. J. Anim. Sci. 81:411-415.

Silva, D. J. and A. C. Queiroz. 2002. Análise de alimentos: métodos químicos e biológicos. Viçosa: UFV. p. 235.

Silva, R. R., F. F. Silva, I. N. Prado, G. G. P. Carvalho, I. Franco, F. Mendes, C. Cardoso, A. Pinheiro, and D. Souza. 2006. Methodology for studying the behavior of calves in confinement during the post-weaning phase. Archivos Latinoamericanos de Producción Animal, 14:135-138.

Van Soest, P. J. 1994. Nutritional ecology of the ruminant. 2.ed. Ithaca: Cornell University Press. p. 476.