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Características produtivas e reprodutivas de ovelhas deslanadas criadas em pastagens na região tropical do Brasil

Reproductive and productive characteristics of hair sheep raised in the tropical region grassland of Brazil

Características productivas y reproductivas de ovejas de pelo criadas en pasturas en la región tropical de Brasil

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Resumo

O objetivo foi caracterizar o perfil energético de ovinos deslanados (*Ovis aries*), criados em pastagens em país de clima tropical, e verificar a possível influência sobre parâmetros produtivos e reprodutivos. Um total de 68 ovelhas adultas, não prenhes foram distribuídas

aleatoriamente em quatro grupos genéticos (GGs), de acordo com a cor da pelagem (Santa Inês - 17 pelagem vermelha, Santa Inês - 13 pelagem preta, Morada Nova - 28 pelagem branca e Morada Nova - 10 pelagem vermelha). As amostras de sangue foram coletadas no início e no final da época de reprodução. A eficiência reprodutiva das ovelhas foi avaliada por fertilidade, prolificidade, taxa de sobrevivência e peso corporal dos cordeiros ao nascer e ao desmame. As análises estatísticas foram realizadas utilizando o pacote PROC GLM e o teste qui-quadrado (χ2) do software SAS. O grupo genético influenciou as concentrações séricas de glicose, β-hidroxibutirato, prolificidade e peso corporal de cordeiros ao nascimento e ao desmame. Os cordeiros machos foram mais pesados que as fêmeas, ao nascimento e ao desmame. Os cordeiros gêmeos foram mais leves ao nascer e ao desmame, em comparação aos cordeiros únicos. O GG, classificação de nascimento e sexo influenciaram o peso corporal do cordeiro ao nascer e ao desmame. Os parâmetros sanguíneos encontrados neste estudo sugerem que existem diferenças metabólicas importantes entre ovelhas deslanadas criadas na região semi-árida do Nordeste do Brasil. Ovelhas Morada Nova de pelagem branca apresentaram maior desempenho reprodutivo em condições tropicais.

Palavras-chave: *Ovis aries*; Sangue; Peso corporal; Perfil energético; Clima tropical.

Abstract

We aimed to characterize the energetic profile of hair sheep (*Ovis aries*) raised on pasture in a tropical climate country and verify it is influence on productive and reproductive parameters. A total of 68 non-pregnant adult ewes were randomly distributed into four genetic groups (GGs) according to coat color (Red-coated Santa Inês GG – 17, Black-coated Santa Inês GG – 13, White-coated Morada Nova GG – 28 and Red-coated Morada Nova GG – 10). We collected blood samples at the beginning and at the end of the breeding season. The reproductive efficiency of the ewes was evaluated by fertility, prolificacy, lamb survival rate, and lamb body weight at birth and weaning. We performed statistical analyses using the package PROC GLM and the chi-square (χ^2) test from SAS software. The genetic group influenced serum glucose and β-hydroxybutyrate concentrations, prolificacy, and lamb body weight. Male *lambs* were heavier than female *lambs at birth* and *weaning.* Twin lambs were lighter at birth and at weaning than were single lambs. The genetic group, lamb birth rank, and sex influenced the lamb body weight at birth and weaning. This study presents important information on the reproductive efficiency of these hair sheep that are relevant to tropical climate countries. The blood parameters found in this research show that there are important metabolic differences between hair sheep in the semi-arid region of Northeast Brazil. Morada

Nova sheep with independent white coat color, higher reproductive performance in tropical conditions.

Keywords: *Ovis aries;* Blood; Body weight; Energetic profile; Tropical climate.

Resumen

El objetivo de este trabajo fue caracterizar el perfil energético de las ovejas de pelo (*Ovis aries*) criadas en pasturas en país de clima tropical y verificar la posible influencia en los parámetros productivos y reproductivos. Un total de 68 ovejas adultas no gestantes se distribuyeron aleatoriamente en cuatro grupos genéticos (GG) según el color del pelaje (Santa Inês GG - 17 con recubrimiento rojo, Santa Inês GG - 13 con recubrimiento negro, Morada Nova GG - 28 con recubrimiento blanco y Morada Nova GG - 10 con revestimiento rojo). Se recogieron muestras de sangre al principio y al final de la temporada reproductiva. La eficiencia reproductiva de las ovejas fue evaluada por fertilidad, prolificidad, tasa de supervivencia y peso corporal del cordero al nacer y al destete. Los análisis estadísticos se realizaron utilizando el paquete PROC GLM y la prueba de chi-cuadrado ($\chi 2$) del software SAS. El grupo genético de las ovejas influyó en las concentraciones séricas de glucosa y β-hidroxibutirato, la prolificidad y el peso corporal del cordero. Los corderos machos eran más pesados que las hembras al nacer y al destete. Los corderos gemelos eran más ligeros al nacer y al destete que los corderos solos. El grupo genético, el rango de nacimiento del cordero y el sexo influyeron en el peso corporal del cordero al nacer y al destete. Este estudio presenta información importante sobre la eficiencia reproductiva de estas ovejas de pelo que son relevante para los países de clima tropical. Los parámetros sanguíneos encontrados en esta investigación muestran que existen importantes diferencias metabólicas entre ovejas de pelo en la región semiárida del noreste de Brasil. Oveja Morada Nova con pelaje blanco independiente, mayor rendimiento reproductivo en condiciones tropicales.

Palabras clave: *Ovis aries;* Sangre; Peso corporal; Perfil energético; Clima tropical.

1. Introduction

The hair sheep flocks raised in the semi-arid region of north-eastern Brazil are exploited for the production of meat and skin, but they present low productive and reproductive performance due to poor management practices and nutrition imposed by the climatic conditions (Silva et al., 2010). In natural grassland, it is difficult to obtain good productivity and quality sheep meat, which demands the use of cultivated pastures,

supplementation in grazing and confinement to exploit the maximum genetic potential of the animals (Sales et al., 2016). These sheep may be affected by metabolic–nutritional unbalances (Catunda et al., 2013), which may be reflected in the concentrations of some blood metabolites (Cardoso et al., 2011). Therefore, evaluation of some blood alterations in the sheep may be an important tool to verify several body systems and to discover the animals' adaptation to nutritional and physiological challenges (David et al., 2012). Moreover, it provides a base for maximizing reproductive potential and to increase the profitability of the production system through better nutritional strategies (Hermuche et al., 2013).

Reproductive efficiency contributes to the increase of the flock size and productivity because it is directly related to fertility, prolificacy, and lamb survival rate (Simplício and Azevedo, 2014). Lamb meat production also is important because more kilograms of lamb *weaned* per ewe mated are desirable (Mexia et al., 2004). For that to be possible requires high fertility, prolificacy, and low mortality rates, which justifies the pressure to increase the number of twin births and to decrease mortality (Siqueira et al., 2001).

The Santa Inês breed is the most popular hair sheep in Brazil and offers good meat production (Rego Neto et al., 2018); it is large, with good growth potential, good milk yield, and low multiple birth rate (Jucá et al., 2014). Morada Nova sheep are an important genetic resource in the northeast of Brazil; it is a small animal, rustic, with high prolificacy (Lacerda et al., 2016) and low-fat accumulation in the lumbar region of the spine (Oliveira et al., 2016). The Brazilian association of sheep farmers (ARCO) recognizes two varieties of Morada Nova hair sheep: Red- and White-coated, which are genetically different (Ferreira et al., 2014). However, despite the growth of the Brazilian sheep flock (Hermuche et al., 2013), the number of Morada Nova hair-breed animals has been reducing annually. The Morada Nova genetic group is not endangered, but the breeding program is still limited (Muniz et al., 2016). Many producers have chosen to purchase other more productive sheep breeds for breeding. This fact has endangered the existence and preservation of this important genotype (Facó et al., 2008).

We hypothesize that the energetic profile and body weight of the lambs at birth and weaning differ among the genetic groups of hair sheep.

We aimed to characterize the energetic profile of the hair sheep raised on pasture in a semi-arid region of Brazil and to verify the possible influence of the genetic group and coat color on fertility, prolificacy, lamb survival rate, and body weight of lambs at birth and weaning.

2. Materials and Methods

The experiment was conducted on the Lavoura Seca Experimental Farm of the Federal University of Ceara (Quixadá, Ceara, Brazil), which is located in a hot semi-arid region at 4º59'S; 39º01'W and is 190 m above sea level. The climate of the region is hot and semi-arid (BSh) with an air temperature ranging from 24 to 28 °C, the relative humidity of 70%, and average annual precipitation of 838.1 mm (IPECE, 2018). The soils of the region are shallow and stony, so they have as main characteristics to absorb water in the rainy season and dry out easily in periods of drought. The predominant vegetation is dense or open shrub caatinga, characterized by the presence of cacti and undergrowth with low trees and thorns.

Throughout the breeding season (60 days; the beginning of the rainy season), a total of 68 non-pregnant adult (4.2 ± 0.9 years old; 32.02 ±7.5 kg initial body weight) were distributed according to genetics groups and color (Red-coated Santa Inês GG – 17, Black-coated Santa Inês GG – 13, White-coated Morada Nova GG – 28 and Red-coated Morada Nova GG – 10). The ewes were first tagged with a tag earring for identification and prophylactic measures against infectious diseases (clostridiosis), and endo- and ectoparasitic infestation were taken to that the animals were in a healthy condition during the study. In the experimental period, all ewes had the same access to natural pasture to ensure the same feeding condition. The animals received supplementation formulated (75% ground corn, 20% soybean meal, and 5% lime) according to the National Research Council (NRC) (2007) and had free access to mineral salt and water.

At night, the females were distributed in four different paddocks according to the genetic group and coat color to allow mating by the respective rams (Red-coated Santa Inês, Black-coated Santa Inês, White-coated Morada Nova and Red-coated Morada Nova) The rams were fed with the same dietary supplementation formulated for the ewes. The separation of Santa Inês ewes by coat color was adopted for didactic purposes and, although the ewes were of the same breed, the black ewes were visibly smaller than the red.

During the trial (at the beginning and end of the breeding season), blood samples were collected from each ewe by jugular venipuncture in non-anticoagulation vacuum tubes (Vacuntainer®) to obtain serum and to determine the glucose, total cholesterol, triglyceride, and β-hydroxybutyrate (β-HB) concentrations. To centrifuge the material, FANEM® model excelsa baby was used at 8000 r.p.m. After the samples were centrifuged, the serum was stored at −20 °C until further analysis. These constituents were assayed in duplicate using colorimetric commercial kits of the BioClin® brand (Bioclin, Quibasa; Belo Horizonte,

Brazil) according to the manufacturer's recommendations. The β-HB was assayed in duplicate using Precision Xtren (Abbott Laboratories Inc., Abbott Park, IL, USA).

The reproductive efficiency of the ewes was evaluated according to fertility (the number of ewes *lambing* per ewes submitted to mating), prolificacy (number of lambs born per ewe *lambing*), lamb survival rate (number of lambs weaned per lambs born), lamb body weight at birth and at weaning at three months old. The body weight was obtained in an appropriate balance for lambs.

A completely randomized design in a 4 × 2 factorial arrangement was used, with four GGs differentiated by coat color (Red-coated Santa Inês, Black-coated Santa Inês, White-coated Morada Nova and Red-coated Morada Nova) and two periods (at the beginning and end of the breeding season), according to the mathematical model:

$$Y_{ijk} = \mu + c_i + r_j + c_i \times r_j + e_{ij},$$

Where: *Yijk*: glucose, total cholesterol, triglycerides and β-hydroxybutyrate concentrations; μ: general mean (glucose, total cholesterol, triglycerides, and β-hydroxybutyrate concentrations); c_i: effect of genetic group (*i*, Red-coated Santa Inês, Black-coated Santa Inês, White-coated Morada Nova and Red-coated Morada Nova); r_j: effect of the period (*j*, at the beginning and end of the breeding season); and e_{ijk}: random error.

The obtained data were submitted to analysis of variance using GLM statistical software (SAS) and the means were compared by lsmeans (Tukey test), significance ≤ 5% (SAS Institute, SAS 9.1, 2004). The descriptive analysis of the information was performed using Proc Univariate to test the distribution and consistency (normal test), followed by obtaining the parameters by breed effect. The mean prolificacy, lamb birth rank, and lamb weight at birth and weaning were compared by the lsmeans (Tukey test) of the statistical software SAS 9.1. The average fertility and lamb survival rate were calculated by the genetic group and summarised in a contingency table to *compare means* using the chi-square test (χ^2) SAS 9.1.

3. Results and Discussion

There was no interaction ($p > 0.05$) among serum glucose and β-hydroxybutyrate concentrations in at the beginning and the end of the breeding season. However, the GG

influenced both serum glucose and β-hydroxybutyrate concentrations ($p < 0.05$; Table 1). Total cholesterol and triglyceride concentrations were influenced by the GG and the collection period (Table 2). At the beginning of the breeding season, the total cholesterol concentrations were lower in the White-coated Morada Nova ewes ($p < 0.05$) and at the end of the breeding season, those females had the highest concentrations ($p < 0.05$). At the end of the breeding season serum, triglyceride concentrations were lower in the two varieties of Morada Nova ewes ($p < 0.05$) than in Santa Inês ewes.

Table 1. Mean ± standard error of serum glucose and β - hydroxybutyrate (β-HB) concentrations in the breeding season in ewes from different genetic groups.

Genetic groups	Glucose (mg/dl)	βHB (mg/dl)
White-coated Morada Nova	81.30 ± 0.90^{a}	1.98 ± 0.19^{b}
Red-coated Morada Nova	76.14 ± 1.48^{b}	2.83 ± 0.30^{a}
Black-coated Santa Inês	78.08 ± 1.30^{b}	2.22 ± 0.27^{ab}
Red-coated Santa Inês	81.26 ± 1.14^{ab}	2.00 ± 0.23^{b}

a, b Lowercase letters: Comparison between genetic groups by the Tukey test ($p<0.05$). Source: Authors.

Ruminants depend almost entirely on hepatic gluconeogenesis to supply their glucose requirements (Heitmann et al., 1987). In these species, gluconeogenesis is a continuous process because almost all dietary carbohydrates are fermented to volatile fatty acids in the rumen (Young, 1977). Propionate is the only major volatile fatty acid that contributes to gluconeogenesis (Mcdonald et al., 2010; Kaneko et al., 2008). In this study, glucose concentrations varied with GG and coat color; such differences can be attributed to a differentiated turnover of glucose, which depends on the rate of hepatic glucose production (gluconeogenesis) and its use by peripheral tissues (Matsuzaki et al., 1997). According to Catunda et al., (2013), these differences explain, in part, the greater dependence of the Santa Inês on food supplementation than the Morada Nova GG when submitted to direct grazing.

β-Hydroxybutyrate is an important alternative energy source for many extrahepatic tissues (Zarrin et al., 2013), and its elevation in the blood is associated with decreased plasma glucose concentrations (Zarrin et al., 2017). In the present study, the GG influenced blood β-HB concentrations. The blood β-HB concentrations in hair sheep in a hot semi-arid region are

below those reported in hair sheep kept in an AW (hot and humid) climate (Pereira et al., 2018) or farmed in temperate climates (5.33 to 6.17 mg/dL; Kaneko et al., 2008). Therefore, it is possible to affirm that in the experimental conditions of this study, the hair sheep showed an excellent metabolic capacity to use acetyl-CoA because an increased blood β-HB concentration is part of the adaptive process of energy metabolism for lower food supply (Pereira et al., 2018). So, it is possible to suggest that hair sheep are efficient animals because their energy requirements have been met, which was confirmed by adequate blood glucose and β-HB concentrations.

Table 2. Mean ± standard error of the blood triglyceride and total cholesterol concentrations at the beginning and end of the breeding season of the different genetic groups from hair sheep.

Genetic groups	Beginning of the breeding season		End of the breeding season	
	Triglycerides (mg/dl)	Cholesterol (mg/dl)	Triglycerides (mg/dl)	Cholesterol (mg/dl)
White-coated Morada Nova	139.54 ± 1.92a	102.70 ± 2.32bB	123.80 ± 1.92bB	109.40 ± 2.32a
Red-coated Morada Nova	141.37 ± 3.16a	117.92 ± 3.81aA	129.50 ± 3.16bB	106.24 ± 3.82b
Black-coated Santa Inês	139.74 ± 2.77a	116.84 ± 3.35aA	139.10 ± 2.77aA	106.78 ± 3.35b
Red-coated Santa Inês	145.47 ± 2.42a	124.31 ± 2.93aA	140.44 ± 2.42aA	105.81 ± 2.93b

[A,B]Uppercase letters: comparison between genetic groups by the Tukey test ($p<0.05$).
[a,b]Lowercase letters: comparison between periods by the Tukey test ($p<0.05$).
Source: Authors.

In this study, the blood lipid concentrations were influenced by GG and the collection period. In sheep, the characteristic blood triglyceride concentrations have not yet been established, although there are reports of variation in concentrations from 13.4 mg/dl (Kozat and Denizhan, 2010) to 24.8–27 mg/dl (Çetin et al., 2003; Deghnouche et al., 2013), 36.1 mg/dl (Carlos et al., 2015), 53 mg/dl (Nour El-Din et al., 2009) and 68.2 mg/dl (Pajor et

al., 2013). The cholesterol concentration was higher than that reported by Kaneko et al. (2008; 52–76 mg/dL). The cholesterol and triglyceride values obtained were much higher than those reported in the literature, therefore suggesting that metabolic adjustment occurred in the hair sheep GGs. According to Ribeiro et al. (2018), the environment and its climatic variables can trigger physiological, biochemical, hematological, and hormonal alterations that result in a reduction in heat production to maintain homoeothermic conditions. The difference among GGs is evidence that adaptive processes occurred due to the environmental conditions of the Brazilian north-eastern semi-arid region, especially in the sheep flocks of Quixadá City. In Quixadá, 80% of the annual precipitation occurs over four months; in the other months, the weather is dry and is associated with high air temperatures and high solar radiation. Another recent study showed that locally adapted breeds can maintain stable physiological parameters under stressful tropical conditions through other mechanisms. However, breeds from temperate regions would be not able to ensure homeostasis if they were submitted to the same conditions as the present study (Leite et al., 2018). On the other hand, when the Morada Nova and Santa Inês breeds are raised in a humid tropical (AW) climate, cholesterol concentrations are similar to those reported as normal (Pereira et al., 2018).

The fertility rate did not differ between GGs ($p > 0.05$) and the greatest prolificacy was observed in Red-coated Morada Nova ewes ($p < 0.05$; Table 3). The Santa Inês ewes produced heavier lambs at birth and weaning ($p < 0.05$) than the Morada Nova ewes. In the experimental conditions of this study, the GG, lamb birth rank, and sex did not influence the lamb survival rate ($p > 0.05$). Male lambs were heavier than female lambs at birth and weaning ($p < 0.05$, Table 4). Twin lambs were lighter at birth and weaning than single lambs ($p < 0.05$).

Table 3. Fertility, prolificacy, lambs survival rate (LSR), lambs body weight at birth (LBWB); lambs body weight at weaning (LBWW) of different genetic groups of the hair sheep.

Item	Red-coated Morada Nova	White-coated Morada Nova	Red-coated Santa Inês	Black-coated Santa Inês
Fertility (%)	82.14 [a]	100[a]	82.35[a]	86.6[a]
(N)	(23/28)	(10/10)	(14/17)	(11/13)
Prolificacy	1.41[ab]	1.64[a]	1.18[b]	1.38[ab]
LSR (%)	86.2 ± 35.10[NS]	100.0 ± 0.00[NS]	87.5 ± 34.16[NS]	84.6 ± 37.55[NS]
LBWB (Kg)	2.80 ± 0.71[b]	1.71 ± 0.49[b]	3.71 ± 0.51[a]	3.48 ± 0.61[a]
(n)	(29)	(14)	(16)	(13)
LBWW (Kg)	7.56 ± 1.79[b]	6.05 ± 1.70[b]	10.58 ± 4.00[a]	9.24 ± 2.09[a]
(n)	(25)	(14)	(14)	(11)

[ab] Lowercase letters: comparison between genetic groups by the Tukey test ($p<0.05$). Fertility and LSR compared by chi-square (χ^2).
[NS] Not significant.
N: number of ewes, n: number of lambs.
Source: Authors.

In the experimental conditions of this study, the breed did not influence fertility rate, as demonstrated by the good fecundity of Brazilian hair sheep breeds (Catunda et al., 2013). The Red-coated Santa Inês sheep showed lower prolificacy. Some studies showed that Red-coated Morada Nova ewes had higher prolificacy than the Somali and Santa Inês hair ewes because of the higher incidence of multiple births (Selaive-Villarroel and Fernandes, 2000). In the current study, the highest frequency of single births was observed in Santa Inês ewes, as already found in other studies (Mexia et al., 2004). In sheep the prolificacy is genetically determined, however, the intensity of gene expression may be influenced by environmental factors such as nutrition (Pokharel et al., 2018). According to Catunda et al. (2013), the Morada Nova ewes are reproductively more efficient than the Santa Inês ewes because they are better adapted to the semi-arid region in a tropical climate than are Santa Inês ewes.

Despite lower prolificacy, Santa Inês ewes produced heavier lambs at birth and at weaning than did the Morada Nova ewes. Morada Nova ewes had lower adult body weight than the Santa Inês ewes (Issakowicz et al., 2016), and large ewes gave birth to heavier lambs than did small ewes (Kenyon et al., 2009). The difference in lamb body weight at weaning can be attributed to the higher milk yield of Santa Inês ewes and the absence of competition for maternal milk that is commonly observed between twin lambs (Jucá et al., 2014). In this species, milk yield in the first four weeks is very important for good lamb growth, and although ewes presenting twin parturitions produce more milk than single parturitions (Abecia and Palacios, 2018), there is no way to provide the same amount of milk to twin lambs that a single-lambing sheep provides (Mexia et al., 2004). Thus, twin lambs, individually, intake less milk than animals born from single parturition (de Castro et al., 2012), resulting in lower body growth (Santello et al., 2010). Although the twin lambs were lighter at birth and at weaning than single lambs, these animals start eating pasture earlier than those born of single parturition (Fernandes et al., 2001). Lower birth body weight may be caused by the higher number of fetuses in the uterus, which results in placental insufficiency (lower placental weight and placentae number) leading to lower fetal development during the final third of the pregnancy (Gootwine et al., 2007). Both genetic and environmental factors may contribute to the variability of this trait (Gootwine, 2005).

Table 4. Mean and standard deviation of the lamb survival rate (LSR), lambs body weight at birth (LBWB), and weaning (LBWW) according to sex and lamb birth rank.

Body weight	Sex		Lamb birth rank	
	Males	Females	Single	Twin
LBWB	3.11 ± 0.89[a]	2.77 ± 0.93[b]	3.26 ± 0.87[a]	2.40 ± 0.76[b]
(n)	(30)	(42)	(43)	(29)
LBWW	9.02 ± 3.01[a]	7.52 ± 2.64[b]	9.21 ± 3.03[a]	6.68 ± 1.87[b]
(n)	(28)	(36)	(38)	(26)
LSR	95.52 ± 6.10	85.00 ± 5.23	90.94 ± 5.16	89.57 ± 6.21

[ab] Different letters on the same line indicate a significant difference by Tukey test ($p < 0,05$).
n: number of lambs.
Source: Authors.

In this study, male lambs were heavier than female lambs at birth and at weaning. In small ruminants, bodyweight is one of the most distinguishing examples of sexual dimorphism (Ghafouri-Kesbi et al., 2015) because it is common for male lambs to be heavier than females at birth and at weaning (De Castro et al., 2012). In male lambs, the bodyweight at birth is a trait more of the mother than of the lamb.

4. Conclusions

The blood parameters found in this study suggest that there are important metabolic differences among hair ewes raised in the semi-arid region of north-eastern Brazil. White-coated Morada Nova ewes showed greater reproductive performance in tropical conditions. This is an important study since research into the reproductive efficiency of these sheep is scarce. More research needs to be carried out with new white dwelling animals, as little is known about their productive physiology.

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