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Maintenance and growth requirements in male and female hair lambs

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ABSTRACT

An experiment was conducted to evaluate the energy and protein requirements of intact male, castrated male and female Morada Nova lambs. The animals were distributed in a completely randomized 3 × 3 factorial design with three sexes (15 intact males, 16 castrated males and 16 females) and three levels of dietary restriction (*ad libitum*, 30% and 60% feed restriction) with an initial body weight (BW) of 14.50 ± 0.89 kg. Four animals per sex were slaughtered at the start of the trial as a baseline group. When the mean BW in the *ad libitum* treatment reached 28 kg, at day 120 of the experiment, all lambs were slaughtered. For all sexes, the net energy requirement for maintenance was 73.0 kcal/kg$^{0.75}$ empty body weight (EBW)/d ($P = 0.17$). The metabolizable energy efficiency for maintenance (k_m) was 0.58. The metabolizable energy efficiency utilization for gain (k_g) was 0.36; 0.25 and 0.28 for intact males, castrated males and females, respectively. The net energy requirement for gain (NEg) differed ($P < 0.01$) between sexes. The NEg was 0.191, 0.198 and 0.276 Mcal/kg$^{0.75}$ EBW/d for intact males, castrated males and females, respectively, with a BW of 20 kg and a body weight gain (BWG) of 100 g. The net and metabolizable protein requirements for maintenance obtained for lambs were 1.06 g/kg$^{0.75}$ BW/d ($P = 0.78$) and 3.46 g/kg$^{0.75}$ BW/d ($P = 0.39$), respectively. The net protein for gain (NPg) differed ($P < 0.01$) between sexes. For animals weighing 20 kg and with an average daily gain of 100 g/d, NPg was 7.08, 7.11 and 6.78 g/d for intact males, castrated males and females, respectively. The net energy and protein requirements for maintenance of Morada Nova lambs slaughtered between 15 and 28 kg did not vary by sex. The net energy for gain increases and the net protein for gain decreased with the increase in body weight in hair lambs.

1. Introduction

Studies in the world have been directed to access the nutritional requirements of sheep (Deng et al., 2014; Xu et al., 2015; Deng et al., 2017). The requirements of sheep raised in tropical climate may be different from wool sheep raised in temperate climate regions (Oliveira et al., 2017). Thus, there is a critical need to assess the energy and protein requirements of these animals for production under tropical conditions worldwide. All production systems use the requirements suggested by the international committees (Costa et al., 2013; Pereira et al., 2014; Galvani et al., 2014; Pereira et al., 2016). However, the equations proposed by the NRC (2007) were primarily developed from wool sheep raised in temperate regions. We believe that in tropical contexts, these requirements may be underestimated or overestimated during the various physiological stages of the animal. The energy requirements for maintenance are known to be influenced by genotype (Valadares Filho et al., 2010), species (CSIRO, 2007), physiological conditions (AFRC, 1993), environmental temperature (NRC, 2000), sex (NRC, 2007) and other factors (Cannas et al., 2004). Recently a meta-analysis published by Salah et al. (2014) involving estimates of energy and protein requirements of sheep, goats and growing cattle indicated that the energy and protein requirements of ruminants raised in the tropics are greater than those reported in international systems.

Hair sheep are important in many production systems in developing

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countries. These ruminants are smaller, usually older at slaughter (Costa et al., 2013) and characterized by their hardiness and ability to adapt to semiarid climate conditions (Rodrigues et al., 2015). Thus, it is necessary to determine the minimum amount of nutrients needed to meet the energy and protein requirements of these sheep in order to maximize their nutrient use. Hair sheep are well adapted to heat, and recent studies conducted by our team using Brazilian hair sheep breeds (Regadas Filho et al., 2013; Costa et al., 2013; Oliveira et al., 2014) led to divergence from the NRC specifications, which suggested that further studies are necessary to determine the requirements of these animals. In addition, studies are needed to establish the differences between sexes regarding the nutrient requirements for maintenance and growth.

Thus, we hypothesized that the energy and protein requirements for maintenance and weight gain would differ between sexes. Therefore, this study was conducted with the objective of determining the net energy and protein requirements for maintenance and weight gain in intact male, castrated male and female Morada Nova lambs subjected to dietary restriction.

2. Material and methods

2.1. Local and ethics considerations

This experimental trial was conducted at the Animal Nutrition Laboratory of the Department of Animal Science of the Federal University of Ceara (UFC) in Fortaleza, CE, Brazil (30°43′02″ S, 33°32′35″ W). During the experimental trial, the mean daily minimum and maximum air temperatures were 25.5 °C ± 0.78 and 31.0 °C ± 1.13, respectively, and the minimum and maximum relative humidity were 55.9% ± 5.64 and 85.0% ± 4.58, respectively.

Humane animal care and handling procedures were followed according to the guidelines and animal care requirements of the Ethics Committee on Animal Research of the Federal University of Ceara, Fortaleza, Brazil (UFC) (Protocol number, 98/2015).

2.2. Animals, diets and experimental design

This study used forty-seven 120 d old hair lambs, comprising 31 intact males and 16 females Morada Nova lambs averaging 14.50 ± 0.89 kg of body weight (BW). The lambs were acquired from one farm in Ceara State, Brazil. Prophylactic measures against sheep infectious diseases (clostridiosis), endo and ectoparasitic infestation (hemoncose and ticks, respectively) were carried out to ensure that the animals were in healthy condition throughout the study. Animals were supplemented with an ADE vitamin (A Vit 20.000.000 IU, D3 5.000.000 IU and E 5.500 IU/100 ml). Posteriorly, 16 intact males were castrated using the Burdizzo method. After an adaptation period of 15 days, four animals of each sex were randomly selected and slaughtered to serve as a baseline group. The remaining lambs (n = 35) were housed in individual stalls (1.50 m × 1.50 m) with feeding troughs for food and water. The lambs were distributed in a completely randomized 3 × 3 factorial design with three sexes (11 intact males, 12 castrated males and 12 females) and three levels of feed restriction (*ad libitum*, 30% and 60%).

The ration offered was formulated to supply the nutritional requirements of late-maturity lambs with a gain of 150 g/d as recommended by the NRC (2007), considering animals with 15 kg of BW. The roughage:concentrate rations was 60:40. The total mixed ration (TMR) was composed of Tifton 85 hay ground in an agricultural chopper and an added concentrate ration composed of ground corn grain, soybean meal and minerals as a loose mixture of single components (Table 1). TMR was provided twice per day (0730 and 1600 h), allowing for up to 10% orts only for animals fed *ad libitum* (3 intact males, 4 castrated male and 4 females), and the intake was registered based on the daily feed supply. The proportional supply of feed for animals in the 30% and 60% feed restriction group was calculated daily in relation to the average intake of animals of the same sex permitted *ad libitum* intake. Feeds and orts were sampled and frozen for subsequent chemical analysis.

Table 1
Ingredient proportions and chemical composition of experimental rations.

Ingredients	% of total ration
Tifton 85 hay	60.0
Ground corn grain	32.72
Soybean meal	6.30
Dicalcium phosphate	0.06
Mineral premix[a]	0.92

Chemical composition (g/kg DM)	Total ration	Tifton 85 hay	Corn ground	Soybean meal
Dry matter	908	913	892	910
Crude protein	169	172	103	509
Ether extract	30.8	25.6	43.2	19.3
Mineral matter	61.9	73.4	13.3	65.9
Neutral detergent fiber	439	668	113	135
NDFap[b]	418	645	98	110
Acid detergent fiber	202	318	26	102
Total carbohydrate	738	752	841	408
Non-fiber carbohydrate	320	58.3	728	273
Total digestible nutrients	674	–	–	–

[a] Composition (1 kg of premix): Calcium, 225 g to 215 g; Phosphorous, 40 g; Sulfur, 15 g; Sodium, 50 g; Magnesium, 10 g; Cobalt, 11 mg; Iodine, 34 mg; Manganese, 1800 mg; Selenium, 10 mg; Zinc, 2000 mg; Iron, 1250 mg; Copper, 120 mg; Fluorine, 400 mg; Vitamin A, 37.5 mg; Vitamin D3, 0.5 mg; and Vitamin E, 800 mg.
[b] Neutral detergent fiber corrected for ash and protein.

2.3. Digestion trial and metabolizable protein intake

To estimate nutrient digestibility, fecal samples from each animal were collected during three consecutive days every 15 days at the following times: at 8 h on the first day, at 12 h on the second day, and at 16 h on the third day. The fecal samples were weighed, put in plastic bags, identified and stored at −20 °C until analysis. Indigestible neutral detergent fiber (iNDF) was used as a marker to estimate fecal dry matter excretion, as described by Casali et al. (2008). The amounts of iNDF in the fecal samples, orts, concentrates and Tifton 85 hay were obtained from the residue after 240 h of rumen incubation in a cow receiving a diet based on Tifton 85 hay (60%) and concentrate (40%) composed of corn meal, soybean meal, limestone, dicalcium phosphate and premix. The incubation was performed using nylon bags with a porosity of 50 μm and a ratio of 15 mg/cm^2 of the sample bag for a total of 3.0 g of sample per g of bag according to Ørskov and McDonald (1979). After incubation in the rumen, the bags and residues were rinsed with clean water until the color was clear. After rinsing, the bags were boiled for 1 h in a neutral detergent solution (Van Soest and Robertson, 1985), dried and weighed, and the residues after neutral detergent solution extraction were considered to be the iNDF (Casali et al., 2008). All samples were frozen at −20 °C. Amounts of total digestible nutrients (TDN) were calculated according Weiss's (1993) equation, and the digestible energy (DE) of the diet was considered to be 4409 Mcal/kg TDN. DE was converted to metabolizable energy (ME) at an efficiency rate of 82% (NRC, 2000). With this information the metabolizable energy intake (MEI) was calculated.

To estimate the rumen microbial crude protein synthesis (MCPs), spot urine samples were collected from all animals at 12 h, every 15 days during the experimental trial. Subsamples of 10 ml of pure urine were collected and diluted in 40 ml of a solution of sulfuric acid 0.036N and stored at −20 °C for to quantify purine derivatives (PD) and creatinine. The creatinine was used for to estimate the urinary volume. The analysis of allantoin in the urine was performed using the