

Assessment of caseous lymphadenitis in goats in a slaughterhouse in the Brazilian semi-arid region and estimates of economic losses due to carcass condemnation

Avaliação da linfadenite caseosa em caprinos em um abatedouro na região do semiárido brasileiro e estimativas de perdas econômicas por condenação de carcaças

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Highlights:

Of 304 goats, 77 (25.33%) had abscesses suggestive of caseous lymphadenitis.

Corynebacterium pseudotuberculosis was isolated in 65 (84.41%) of the 77 animals with abscesses.

Caseous lymphadenitis caused condemnations of R\$ 4,540.33/kg.

Sex affected carcass and viscera weights and carcass yield.

Age of the animals affected live, carcass, organ, and viscera weights.

Abstract

Caseous lymphadenitis (CLA) caused by the pathogenic bacterium, *Corynebacterium pseudotuberculosis*, results in economic loss in goat farming. Its prevalence in Brazilian herds varies from 5 to 50%, generating expenses with treatment, loss in production, carcass and organ condemnation, and reduced price of the hide. This study aimed to describe the distribution of lesions and quantify the loss associated with CLA in goat breeding due to condemnation in a slaughterhouse located in a semiarid region. The study was conducted at the municipal slaughterhouse of the city of Patos, State of Paraíba, Northeastern Brazil, where goats from this intermediate geographical region are slaughtered. In 2017, 3,662 animals were slaughtered, an average of 305 per month. During the study period, from March to August 2017, 304 goats of both sexes and different ages of undefined breed were assessed. In the *ante-mortem* examination, inspection and palpation of the superficial lymph nodes was done; in the *post-mortem* examination, organ and viscera were assessed. The caseous material collected was sent for microbiological analysis. Of the 304 individuals, 227 [74.67% (95% CI: 69.50-79.23)] did not have any lesions, while 77 [25.33% (95% CI: 20.77-30.50)] showed abscesses suggestive of CLA, which was confirmed in 65 goats [84.41% (95% CI: 76.30-92.50)]. Sex ($P = 0.044$) and age ($P = 0.002$) were

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associated with infection. While the sex of the animals affected carcass and viscera weights and carcass yield, their age affected live weight, carcass, organ, and viscera weights; conversely, the incidence of CLA did not affect these variables. The average price in Real (R\$) of a kilogram (kg) of goat meat cuts and “offal” was used to calculate the economic loss. Considering the average carcass weight (11,485 kg), organ weight (1,085 kg), and viscera weight (2,013 kg), 4,433.232 kg of meat was produced, resulting in R\$ 72,945.43. The condemnations resulted in the loss of 269.894 kg, which is equivalent to R\$ 4,540.33. CLA is responsible for a negative impact of 6.09% on production. Implementing control measures for this disease is important to increase the financial return in goat farming.

Key words: Goat farming. *Corynebacterium pseudotuberculosis*. Condemnation. Financial loss.

Resumo

Linfadenite Caseosa (LC) causada pela bactéria patogênica *Corynebacterium pseudotuberculosis* resulta em perda econômica na caprinocultura. No rebanho brasileiro sua prevalência varia de 5 a 50%, gerando gastos com tratamento, queda de produção, condenação de carcaça e órgãos, e desvalorização da pele. O objetivo deste trabalho foi quantificar a perda associada à LC na caprinocultura de corte por condenação em abatedouro do semiárido, bem como caracterizar a distribuição das lesões. O trabalho foi realizado no Abatedouro Municipal da cidade de Patos, Estado da Paraíba, Nordeste do Brasil, onde ocorre abate de caprinos provenientes desta região geográfica intermediária. No ano de 2017 foram abatidos 3.662 animais, uma média de 305 por mês. Durante o período de estudo, março a agosto do mesmo ano, avaliou-se 304 caprinos sem padrão racial definido, ambos os sexos e idades diversas. No exame *ante mortem* foram submetidos à inspeção e palpação de linfonodos superficiais; *post mortem*, órgãos e vísceras. O material caseoso coletado foi submetido à análise microbiológica para diagnóstico. Dos 304 indivíduos, 227 [74,67% (IC 95%: 69,50-79,23)] não apresentaram qualquer lesão, enquanto 77 [25,33% (IC 95%: 20,77-30,50)] evidenciaram abscessos sugestivos de LC, com confirmação em 65 [84,41% (IC 95%: 76,30-92,50)]. Constatou-se associação de sexo ($P = 0,044$) e idade ($P = 0,002$) à infecção. Foi verificado efeito do sexo dos animais nas variáveis peso de carcaça, peso de vísceras e rendimento de carcaça, bem como houve efeito da idade nas variáveis peso vivo, peso de carcaça, peso de órgãos e peso de vísceras; no entanto, não houve efeito da ocorrência de LC nessas variáveis. Para cálculo de perda econômica adotou-se o preço médio em Real (R\$) do quilograma (kg) dos cortes de carne caprina, e “miúdos”. Considerando o peso médio de carcaça (11,485 kg), órgãos (1,085 kg) e vísceras (2,013 kg), houve produção de 4.433,232 kg, resultando em R\$ 72.945,43. As condenações subtraíram 269,894 kg, equivalente a R\$ 4.540,33. Atribui-se à LC um impacto negativo de 6,09% na produção. Implementar medidas de controle para essa doença é importante para que se amplie o retorno financeiro à atividade.

Palavras-chave: Caprinocultura. *Corynebacterium pseudotuberculosis*. Condenação. Prejuízo financeiro.

Introduction

In Brazil, goat farming is important for agribusiness. The 2017 Agricultural Census showed a national goat herd of 8,254,561 units, most of them located in the northeastern region of Brazil, which, even when facing a long period of drought, holds approximately 93% of the total of country's goats (equivalent to 7,660,715 animals). Paraíba has 545,994 goats and occupies the fifth position

of the states with the largest herds in the country (Instituto Brasileiro de Geografia e Estatística [IBGE], 2018). Although goat farming accounts for a significant number of animals, production is still considered low and has some vulnerabilities, such as health problems, that contribute to the onset and dissemination of diseases, damaging the entire production chain (Alves et al., 2017; Guilherme et al., 2017; Santos, Figueiredo, Beltrão, & Alfaro, 2012; Teixeira et al., 2015).

Among the diseases affecting goats in the semiarid northeast, attention should be paid to infectious diseases, such as caseous lymphadenitis (CLA) (Riet-Correa et al., 2013). CLA is an emerging zoonosis affecting people who have contact with infected animals or contaminated dairy products (Faccioli-Martins, Alves, & Pinheiro, 2014). The infection is caused by *Corynebacterium pseudotuberculosis*, a Gram-positive, non-sporulating, aerobic, and facultative intracellular macrophage parasite. Infection occurs by the penetration of the bacteria through the skin, or by oral or respiratory routes, resulting in a chronic, pyogenic infection with lymph node hypertrophy, abscesses outside lymph nodes, and/or organ involvement (Oreiby, 2015).

For more than a century, its diagnosis has been a matter of intense research. There is no single test that can identify all cases, or even different stages. Microbiological isolation is considered the gold standard but this is limited to clinical cases. There are also tests such as the Enzyme Linked Immunosorbent Assay (ELISA), which is based on the detection of IgG as a humoral activity marker, the quantification of interferon- γ (IFN- γ), which indicates a cell-mediated response, and polymerase chain reaction (PCR) for the detection of genetic material from *C. pseudotuberculosis* (Oreiby, 2015) through the 16S rRNA, rpoB, pld, and 12S rRNA markers (Pacheco et al., 2007).

The economic loss in slaughterhouses occurs due to the prohibition of the consumption of carcasses and organs, compromising productivity in many countries (Windsor & Bush, 2016). In Brazil, the prevalence varies from 5 to 50%, causing (in addition to disposal), reduced production, treatment expenses, and reduced price of the hide (Souza, Carvalho, Garino, & Riet-Correa, 2011; Farias et al., 2018). It is endemic in developed countries; in Australia, with a strong tradition in sheep farming, its prevalence may reach 40% (Paton, 2010).

Limited scientific papers address the economic losses caused by this disease in goat farming. Given

the importance of this activity for Northeast Brazil and the scarcity of information on economics of loss, this study aimed to describe the distribution of lesions and quantify the loss associated with CLA in goat farming due to condemnation in a slaughterhouse located in the semiarid region.

Material and Methods

The study was conducted at the municipal slaughterhouse of the City of Patos (latitude 7°00'19"S and longitude 37°16'48"O), State of Paraíba, Brazil, where goats from this intermediate geographical region are slaughtered. According to data from the Animal Transit Guide (Guia de Trânsito Animal - GTA) provided by the Secretariat for the Development of Agriculture and Fisheries (SEDAP - PB), in 2017, 3,662 goats were slaughtered at an average of 305 per month. In the study period (March to August), 1,269 animals were slaughtered at an average of 212 per month.

Sampling was calculated based on the minimum sample number (N). The simple random sample formula was used, with an expected prevalence of 50% for sample maximization, confidence level of 95%, and sampling error of 6% (Thrusfield, 2007). The formula showed that the minimum number of animals was 267. However, 304 goats of both sexes and different ages of undefined breed were used. At the slaughterhouse, in the *ante mortem* examination, parotid, submandibular, prescapular, prefemoral, and mammary superficial lymph nodes were palpated, forming two groups that were followed at slaughter, one with clinical symptoms suggestive of CLA and the other healthy. The sample was stratified into five age groups (up to 12 months, 12-24 months, 24-36 months, 36-48 months, and > 48 months) according to the dental chronology adapted from Frandson, Lee and Fails (2011), in which age is assigned according to the replacement of deciduous incisors by permanent ones: \leq 12 months - exclusively deciduous; 12-24 months - two tooth; 24-36 months - four tooth; 36-48 months - six tooth;

≥ 48 months - full mouth (complete transition of all eight incisors). The animals included in the study were identified by the placement of a permanent ear tag on the right ear, and live weight after fasting in lairage was recorded.

Acetate labels (45 x 30 mm) and white adhesive paper (25 x 15 mm) (Artgraf Etiquetas[®], Itapira, São Paulo, Brazil), with the corresponding numbers sealed with adhesive tape (Adelbras[®], Vinhedo, São Paulo, Brazil) were used to identify the carcass, organs (heart, lung, esophagus, liver, and spleen) and viscera (rumen, reticulum, omasum, abomasum, and intestines). During the *post-mortem* examination performed by the technically responsible veterinarian of the establishment, dead weight and weight at slaughter (warm weight) were recorded.

The criterion for condemnation was based on current legislation - Art. 193. of Federal Decree 9.013, March 29, 2017 (Regulation of the Industrial and Sanitary Inspection of Animal Products - RIISPOA) - by which the carcass with caseous lymphadenitis abscesses is condemned when lymph nodes from different regions are compromised. Conditional use may be possible through heat sterilization when localized, caseous or calcifying lesions are present, condemning the lymph node drainage area. In case of calcified and discrete lesions, it can be used for human consumption, once the lymph drainage area is discarded. If organs and viscera are compromised, they must be condemned (Ministério da Agricultura, Pecuária e Abastecimento, 2017).

Samples of the granulomas were stored in Ziploc N9 200 x 280 mm plastic bags (Talge[®], Itajaí, Santa Catarina, Brazil). They were duly identified and sent to the Laboratory of Communicable Diseases (Laboratório de Doenças Transmissíveis) under refrigeration, at the Center for Health and Rural Technology (Centro de Saúde e Tecnologia Rural), Federal University of Campina Grande, Campus de Patos, where they were immediately processed.

A 5% sheep blood, solid agar medium (Himedia[®], Mumbai, Maharashtra, India), pH 7.0-

7.2, was placed in glass Petri dishes, and brain heart infusion - BHI fluid medium (Himedia[®], Mumbai, Maharashtra, India) was placed in test tubes (10 ml) with a screw cap to be used for microbiological culture (Oreiby, 2015). The abscesses were cut lengthwise with sterile scalpel blades (No. 24). The caseous content was sown in blood agar as the primary culture using a platinum handle. Samples were incubated aerobically at 37 °C (Fanem[®] 502 incubator) and readings were taken at 24 and 72 hours. Subsequently, transplantation took place in BHI for biochemical identification.

The isolated microorganisms (small, white-yellowish colonies) were subjected to the catalase test with 3% hydrogen peroxide, urease, and reverse CAMP, producing a positive result. They were then subjected to bacteriological examinations by the Gram method. *Corynebacterium pseudotuberculosis* was identified based on the *Manual of Clinical Microbiology* (Murray, Baron, Pfaller, Tenover, & Tenover, 1999).

The average price in Real (R\$) of the kilogram (kg) of goat meat cuts, and “offal” (organs/viscera) was considered to calculate the economic loss. They were obtained through research conducted in ten establishments, comprising slaughterhouses and supermarkets, in a 10 km radius from the central region of the city of Patos. The amount lost was calculated based on the loss due to the carcass and organ condemnations due to the presence of caseous material, from which *C. pseudotuberculosis* was isolated.

The chi-squared test was used to compare qualitative variables (gender and age) with the incidence of CLA. The General Linear Model was used with multiple comparisons by the Tukey HSD test to determine the effect of sex, age, and the occurrence of CLA on the quantitative variables live weight, carcass weight, organ weight, viscera weight, and carcass yield. The level of significance used was 5% and the analyses were performed in SPSS[®] for Windows version 20.

Results

Of the 304 goats, 227 [74.67% (95% CI: 69.50-79.23)] did not show granulomatous changes in *ante* and *post-mortem* inspections, while 77 [25.33% (95% CI: 20.77-30.50)] had abscesses suggestive of caseous lymphadenitis, of which 65 [84.41% (95% CI: 76.30-92.50)] had *C. pseudotuberculosis*.

Of the infected animals, 53.85% (35/65) exhibited external lesions, while 46.15% (30/65) exhibited internal lesions. It is important to emphasize that four individuals had clinical CLA and internal

involvement concomitantly. Some goats with the clinical form of the disease showed involvement of more than one lymph node and/or abscess. Similarly, some goats with the subclinical form of the disease showed involvement of more than one organ. The most affected superficial lymph node was the prefemoral at 27.03% (10/37), highlighting the presence of abscesses outside the lymph nodes (neck, ribs, scapular region, and flank) at 21.62% (8/37). Internal lesions were more common in the liver, at 66.67% (22/33), and in the lung, at 18.18% (6/33) (Table 1).

Table 1

Frequency of external and internal lymph nodes affected by *Corynebacterium pseudotuberculosis* in goats in the Brazilian semiarid region, considering the body distribution of abscesses

| External | | | Internal | | |
|-------------------------------|--------------------|----------------|---------------------------|--------------------|---------|
| Place | Total (%) | | Place | Total (%) | |
| Lymph. Prefemoral | 10 | (27.03) | Liver | 22 | (66.67) |
| Lymph. Prescapular | 5 | (13.51) | Lung | 6 | (18.18) |
| Lymph. Mammary | 4 | (10.81) | Lymph. Middle Mediastinum | 3 | (9.09) |
| Lymph. Parotid | 4 | (10.81) | Spleen | 2 | (6.06) |
| Lymph. Submandibular | 3 | (8.11) | - | - | - |
| Lymph. Axillary | 2 | (5.41) | - | - | - |
| Lymph. Retropharyngeal | 1 | (2.70) | - | - | - |
| | 29 | (78.38) | - | - | - |
| Outside the lymph node | | | - | - | - |
| Neck | 3 | (8.11) | - | - | - |
| Rib | 3 | (8.11) | - | - | - |
| Scapular region | 1 | (2.70) | - | - | - |
| Flank | 1 | (2.70) | - | - | - |
| | 8 | (21.62) | - | - | - |
| Total | 37 (100.00) | | | 33 (100.00) | |

Age ($p = 0.002$) and sex ($p = 0.044$) were associated with infection. Females were more affected (26.49%) than males (16.34%). Animals > 48 months presented a higher percentage of positives (39.39%) (Table 2).

Table 2
Frequency of caseous lymphadenitis in goats of the Brazilian semiarid region according to the qualitative variables gender and age

| Variable | Category | Total no. of animals (%) | No. of animals + (%) | P |
|----------|----------------|--------------------------|----------------------|-------|
| Sex | Male | 153 (50.33) | 25 (16.34) | 0.044 |
| | Female | 151 (49.67) | 40 (26.49) | |
| Age | ≤ 12 months | 131 (43.09) | 19 (14.50) | 0.002 |
| | 12 - 24 months | 47 (15.46) | 9 (19.15) | |
| | 24 - 36 months | 28 (9.21) | 6 (21.43) | |
| | 36 - 48 months | 32 (10.53) | 5 (15.63) | |
| | > 48 months | 66 (21.71) | 26 (39.39) | |

No. = number; + = positive; with caseous lymphadenitis.

In the retail trade in the central area of the city of Patos - Paraíba, the average price in Real (R\$) of a kilogram (kg) of goat meat was 17.27, “buchada de bode” price was R\$ 18.33, and “offal” price was R\$ 13.43 (Table 3).

Table 3
Result of market research on the average price in Real (R\$) of a kilogram (kg) of goat meat cuts (*‘buchada’*), and offal in the retail trade of Patos, Paraíba

| Cuts | Price (R\$/kg) |
|-----------------|----------------|
| Neck | 16.98 |
| Shoulder clod | 17.69 |
| Chest | 16.61 |
| Rib | 16.45 |
| Flank steak | 17.60 |
| Anterior loin | 17.48 |
| Posterior loin | 17.70 |
| Ham | 17.64 |
| | 17.27 |
| <i>Buchada*</i> | 18.33 |
| Offal** | 13.43 |

Average price obtained through research conducted in ten commercial establishments. Buchada* = typical regional culinary dish prepared with organs and viscera of goat. Offal** = edible organs (heart, lung, esophagus, liver, and spleen) and viscera (rumen, reticulum, omasum, abomasum, and intestines).

The slaughter of 304 goats generated 3,491.440 kg of carcass, 329.840 kg of organs, and 611.952 kg of viscera, totaling 4,433.232 kg, or R\$ 72,945.43. The slaughter of 304 goats generated 254.296 kg, 468.201 kg, respectively; for positive animals, these values were 804.310 kg, 75.595 kg, and 143.780 kg (Table 4). Infection-free animals accounted for 2,687.077 kg,

Sixteen complete carcasses, five necks, one shoulder clod, one breast, three ribs, six hams, and organs of 30 goats were condemned. The disposal reached 269.894 kg, which represents 26.39% of the production of the sick group, or 6.09% of total

production, resulting in the amount of R\$ 4,540.33. Some animals with the disease were not discarded, as their granulomas were located in regions that are not part of the carcass (Table 5).

Table 4

Average live weight, carcass weight, carcass yield, organs and viscera weights of Brazilian semiarid goats according to age, condition of the animal (with and without CLA), and sex

| Age | Condition | Sex | N | LW (kg) | Carcass (kg) | Disposal | CY (%) | Organs (kg) | Disposal | Viscera (kg) | Disposal |
|-----------------------|-----------|-----|------------|---------------|---------------|--------------|-----------|--------------|--------------|--------------|----------|
| ≤ 12 months | Without | M | 80 | 19.765 | 8.968 | | 45 | 0.871 | | 1.635 | |
| | With | M | 14 | 19.421 | 8.750 | 3.412 | 45 | 0.914 | 0.314 | 1.607 | - |
| | Without | F | 32 | 17.975 | 8.428 | | 47 | 0.850 | | 1.506 | |
| | With | F | 5 | 20.880 | 9.040 | 2.429 | 43 | 0.840 | 0.320 | 1.580 | - |
| 12 - 24 months | Without | M | 19 | 23.347 | 10.768 | | 46 | 1.021 | | 1.905 | |
| | With | M | 5 | 25.040 | 10.160 | 4.360 | 41 | 0.800 | 0.520 | 1.840 | - |
| | Without | F | 19 | 22.489 | 10.000 | | 44 | 0.995 | | 1.758 | |
| | With | F | 4 | 19.725 | 8,200 | 1.107 | 42 | 0.850 | 0.450 | 1.400 | - |
| 24 - 36 months | Without | M | 16 | 27.656 | 12.706 | | 46 | 1.088 | | 2.031 | |
| | With | M | 3 | 25.867 | 12.467 | 1.433 | 48 | 1.000 | 0.600 | 1.867 | - |
| | Without | F | 6 | 26.983 | 11.933 | | 44 | 1.033 | | 1.900 | |
| | With | F | 3 | 27.133 | 12.867 | 4.133 | 47 | 1.267 | 0.400 | 1.833 | - |
| 36 - 48 months | Without | M | 8 | 31.225 | 15.400 | | 49 | 1.375 | | 2.413 | |
| | With | M | 2 | 37.350 | 17.400 | - | 47 | 1.400 | 1.400 | 3.300 | - |
| | Without | F | 19 | 30.963 | 13.179 | | 43 | 1.216 | | 2.274 | |
| | With | F | 3 | 29.867 | 11.200 | 0.444 | 37 | 1.000 | 0.533 | 1.567 | - |
| > 48 months | Without | M | 5 | 37.620 | 16.860 | | 45 | 1.560 | | 2.680 | |
| | With | M | 1 | 35.400 | 15.000 | 15.000 | 42 | 1.500 | - | 2.600 | - |
| | Without | F | 35 | 37.697 | 16.360 | | 43 | 1.531 | | 2.854 | |
| | With | F | 25 | 36.440 | 15.744 | 4.705 | 43 | 1.484 | 0.612 | 2.944 | - |
| Mean (Without) | | | 239 | 25.010 | 11.243 | | 45 | 1.064 | | 1.959 | - |
| Mean (With) | | | 65 | 28.463 | 12.374 | 3.643 | 43 | 1.163 | 0.509 | 2.212 | - |
| Mean (Overall) | | | 304 | 25.748 | 11.485 | | 45 | 1.085 | | 2.013 | - |

N = number of individuals; LW = live weight; CY = carcass yield; Without = absence of CLA; With = presence of CLA; M = male; F = female.

Table 5
Result of the economic damage resulting from the losses due to condemnations of carcasses, cuts, and organs of goats of the Brazilian semiarid region affected by caseous lymphadenitis

| Condemnation | Total | Weight (kg) | Price (R\$/kg) | Loss (R\$) |
|---------------------|--------------|--------------------|-----------------------|-------------------|
| Carcass | 16 | 209.000 | 17.27 | 3,609.43 |
| Neck (Fragment) | 5 | 1.784 | 16.98 | 30.29 |
| Shoulder clod | 1 | 1.426 | 17.69 | 25.23 |
| Chest (Fragment) | 1 | 0.300 | 16.61 | 4.98 |
| Rib | 3 | 2.104 | 16.45 | 34.61 |
| Ham | 6 | 22.180 | 17.64 | 391.26 |
| Kid | 30 | 33.100 | 13.43 | 444.53 |
| Total | 62 | 269.894 | | 4,540.33 |

Table 6 presents the results of the General Linear Model for the quantitative variables live weight, carcass, organ and viscera weights, and carcass yield. While the sex of the animals affected carcass

weight, viscera weight, and carcass yield, their age affected live weight, carcass weight, organ weight, and viscera weight. The occurrence of CLA did not affect the quantitative variables.

Table 6
Results of the General Linear Model on the effect of sex, age, and occurrence of caseous lymphadenitis on the quantitative variables live weight, carcass, organs, and viscera weight, and carcass yield in goats of various ages

| Variable | Category | Live weight | | | Carcass | | | Organs | | | Viscera | | | CY | |
|----------|----------------|---------------------|----------------|--|---------------------|----------------|--|----------------------|----------------|--|----------------------|----------------|--|---------------------|----------------|
| | | Average (kg) | Standard error | | Average (kg) | Standard error | | Average (kg) | Standard error | | Average (kg) | Standard error | | Average (kg) | Standard error |
| Sex | Male | 28.269 ^a | 0.726 | | 12.847 ^a | 0.373 | | 1.152 ^a | 0.042 | | 2.187 ^a | 0.072 | | 45.45% ^a | 0.73% |
| | Female | 27.072 ^a | 0.554 | | 11.695 ^b | 0.284 | | 1.106 ^a | 0.032 | | 1.961 ^b | 0.055 | | 43.38% ^b | 0.56% |
| Age | ≤ 12 months | 19.654 ^a | 0.637 | | 8.796 ^a | 0.327 | | 0.868 ^a | 0.036 | | 1.582 ^a | 0.063 | | 45.05% ^a | 0.64% |
| | 12 - 24 months | 22.650 ^b | 0.845 | | 9.782 ^b | 0.434 | | 0.916 ^{a,b} | 0.048 | | 1.725 ^{a,b} | 0.084 | | 43.21% ^a | 0.85% |
| | 24 - 36 months | 26.909 ^c | 1.074 | | 12.493 ^c | 0.552 | | 1.096 ^{b,c} | 0.062 | | 1.907 ^b | 0.107 | | 46.55% ^a | 1.08% |
| | 36 - 48 months | 32.351 ^d | 1.141 | | 14.294 ^c | 0.586 | | 1.247 ^c | 0.066 | | 2.388 ^c | 0.113 | | 44.00% ^a | 1.15% |
| | > 48 months | 36.789 ^e | 1.278 | | 15.991 ^d | 0.657 | | 1.518 ^d | 0.074 | | 2.769 ^d | 0.127 | | 43.25% ^a | 1.29% |
| CL | Without | 27.629 ^a | 0.402 | | 12.460 ^a | 0.206 | | 1.154 ^a | 0.023 | | 2.095 ^a | 0.040 | | 45.26% ^a | 0.41% |
| | With | 27.712 ^a | 0.820 | | 12.082 ^a | 0.421 | | 1.105 ^a | 0.047 | | 2.053 ^a | 0.081 | | 43.56% ^a | 0.83% |

CY = carcass yield. Different lower-case letters in the same column for each variable indicate statistical difference between means ($P < 0.05$).

Discussion

C. pseudotuberculosis is the main agent involved in cases of lymph node hypertrophy in goats (Chirino-Zárraga, Scaramelli, & Rey-Valeirón, 2006). In the current study, this agent was isolated in 84.42% of the goats with abscess(es). The prevalence was 21.38%, surpassing that observed in two other studies in the State of Paraíba: Andrade, Santos Azevedo, Teles, Higino and Oliveira Azevedo (2012) reported a prevalence of 7.66% in the municipalities of Piancó and Itaporanga; Souza et al. (2011) reported a prevalence of 15.88% in the municipality of Mulungu.

The high frequency of infected animals (21.38%), of which 53.84% (35/65) had the clinical form of the disease (external lesions), indicates high risk of transmission. According to Andrade et al. (2012), the rupture of the granuloma increases the risk of contagion by eight times in those susceptible, since the released caseous content keeps the agent in the environment. The early identification of animals with external abscesses for treatment and their isolation until wound healing, associated or not with slaughter, and the use of vaccines, among other strategies, are known to prevent transmission.

In this study, sex and age influenced the occurrence of CLA, which is more common in older females. Reproduction (herd replacement) and milk production (common activity in the region) explain the longevity of this group, which in turn explains the result, i.e. the longer the lifespan, the greater the probability of contact with *C. pseudotuberculosis*.

There were more goats over 48 months and kids under 12 months of age, and these groups had the highest prevalence of CLA. According to Barnabé et al. (2019) this can be explained by the nannies that remain on the property for a longer time depending on their productive viability (reproduction and milk), and are replaced when necessary (in this case, above 48 months), increasing the probability of contact with the agent. This makes them a possible source of reinfection for the herd. The bucks, in

contrast, are sent to slaughter when still young in compliance with market requirements (mostly < 12 months of age, when their meat is of a higher quality and free of *sui generis* odor). According to Riet-Correa et al. (2013) producers do not separate animals by sex and age group, so that young goats have contact with sick adults, which may explain the high prevalence of positive kids in this study.

The average weight of carcass (12.374 kg), organs (1.163 kg), and viscera (2.212 kg) of goats with CLA was higher than that of healthy goats. This may be because most of the discarded animals were nannies over 48 months, i.e., 25 animals representing 38.46% of those infected (25/65). Older goats have a higher live weight, thus larger carcasses, organs, and viscera when compared to younger ones. The 25 goats raised the average of infected goats, being responsible for 48.94% of the total carcass weight (911,000 kg/1,778.095 kg), 49.08% of the organs (37,100 kg/75,597 kg), and 51.18% of the viscera (73,600 kg/143,799 kg). The opposite occurred with the healthy goats, i.e., bucks aged 12 months or less were more susceptible to infection, accounting for 80 individuals, who represented 33.47% of the 239 individuals. These 80 kids decreased the general average, and even though they were the most prevalent group, they accounted for only 26.59% of the total carcass weight (714,400 kg/2,687.100 kg), 27.41% of the organ weight (69,700 kg/254,300 kg), and 27.93% of the viscera weight (130,800 kg/468,300 kg).

It cannot be said that healthy goats will always have higher live weight, and a larger carcass, organs, and viscera. Although the sample animals were of undefined breeds, individual (genetic) capacity for food conversion/weight gain, and the influence of external factors must be considered. Coming from different farms, they may have been subjected to different husbandry systems and diet regimes. In a semi-intensive regime, besides receiving native plants and/or hay as a food source, they are supplemented with energy and/or protein concentrate, which substantially improves their

productive performance. Each production unit has unique characteristics such as level of technology and prophylactic measures (quarantine, vaccination, antihelminthics), which are influenced by the socioeconomic condition of the goat farmer.

Machado, Gressler, Klrinus and Herrmann (2011) followed the total number of condemnations in sheep slaughtered under Federal Inspection in Rio Grande do Sul for five years and concluded that the infection caused the discard of 0.09% (86/932,547) of carcasses, or in cash, R\$ 12,975.27. These authors only considered the rejection of the whole carcass for calculation. It is emphasized that the current legislation in the period of the study was the Decree 30.691, of 1952 (Ministério da Agricultura, Pecuária e Abastecimento, 2017), in which the body score of the animal influenced the destination of the carcass. This criterion is different in the current legislation (Art. 193. of Federal Decree 9.013, March 29, 2017).

In this study, the percentage of condemned animals was higher (6.09%), with disposal of the whole carcass being responsible for 77.44% (209,000 kg/269.894 kg), totaling R\$ 3,609.43. The weight of the condemned organs (33,100 kg) represented 12.26% of the total discarded. This can be justified by the high percentage of individuals with the subclinical form of the disease, 46.15% (30/65). Belchior, Gallardo, Abalos, Jodor and Jensen (2006) collected data on CLA in sheep slaughtered under Federal Inspection in Argentina between 2000 and 2005 and found a prevalence of 7-11% when assessing liver and lung lesions. Although this percentage is similar to the percentage of disapproval of these organs in the present study (9.21%), it should be noted that the legislation regulating slaughter inspection in Argentina may differ from the Brazilian one. In the northeastern region of Brazil, the consumption of "offal" is high, mainly for the preparation of "buchada de bode", a typical regional cuisine. Considering the total weight of condemned organs referring to the amount of

buchada that could no longer be produced (33,100 kg), R\$ 606.72 was lost in income.

In 2017, the monthly average of goats slaughtered at the Municipal Slaughterhouse in the city of Patos was 305. Considering the general average of carcass (11,485 kg), organs (1,085 kg), and viscera (2013 kg), one can estimate a production of 4,447.815 kg (R\$ 73,185.39). Considering a rate of condemnation of 6.09%, distribution of granulomatous lesions, and the average price of the kilogram (kg) of goat meat cuts and "offal" in Real (R\$), disposal reaches 270.872 kg [77.44% correspond to condemnations of whole carcass (209.757 kg/R\$ 3.622.51), 0.66% neck (1.790 kg/R\$ 30.40), 0.53% shoulder clod (1.431 kg/R\$ 25.32), 0.11% breast (0.301 kg/R\$ 5.00), 0.78% rib (2.112 kg/R\$ 34.74), 8.22% ham (22.260 kg/R\$ 392.67), and 12.26% offal (33.220 kg/R\$ 446.14), totaling a loss of R\$ 4.556.78 per month. The annual loss can be estimated at 3,250.464 kg from the total production (53,373.780 kg), or R\$ 54,681.36.

Considering the State of Paraíba, with a herd of 545,994 goats (IBGE, 2018), and a prevalence of 21.38%, 116,734 goats could be affected. Considering the carcass (12.374 kg), organs (1.163 kg), and viscera (2.212 kg) of sick animals and a decrease of 26.39% per disposal, the economic damage reaches R\$ 8,161,762.53 (eight million, one hundred and sixty-one thousand, seven hundred and sixty-two reals, and fifty-three cents). In the Northeastern region, the negative impact amounts to R\$ 114,515,330.02 (one hundred and fourteen million, five hundred and fifteen thousand, three hundred and thirty reals, and two cents). In Brazil, it amounts to R\$ 123,392,349.72 (one hundred and twenty-three million, three hundred and ninety-two thousand, three hundred and forty-nine reals, and seventy-two cents). In addition to rejection at slaughter, expenditure for the treatment of abscesses can also be considered. According to Faccioli-Martins et al. (2014) the amount per unit treated may reach R\$ 10.06.

Data from the Department of Agriculture and Food of the State of Western Australia show that between 1991 and 1992, CLA caused a loss of US\$ 30-35 million in goat production systems in Australia. The drop in wool production totaled US\$ 15-20 million. About 1% of the carcasses were totally condemned (US\$ 1 million). “Trimmed” carcasses, i.e., that had discarded parts, were responsible for an additional loss of US\$ 1-3 million. Disease inspection represents the biggest cost for slaughterhouses (US\$ 10 million): inspectors spend 75% of their time checking and removing granulomas from carcasses (Paton, 2011). Additional spending on vaccination programs throughout Australia should also be noted (Paton, 2010).

It was found that while the sex of the animals affected carcass and viscera weights and carcass yield, age affected live, carcass, organ, and viscera weights; conversely, the occurrence of CLA did not affect these variables. The effect of sex and age is a plausible factor considering that males of this age group tend to have a higher rate of deposition of muscle mass and fat tissue compared to females, which affects live, carcass, organ, and viscera weights and carcass yield (Cézar & Sousa, 2007). Although CLA did not directly influence these quantitative variables, it was associated with gender and age, which may indicate an indirect effect.

An efficient control program should be based on the integration of management practices to prevent the dissemination of the agent to individuals and the environment (Windsor, 2011). For Paton (2011) vaccination is the most effective way. According to Windsor (2011), the prevalence of infection can be reduced by approximately 10 times through vaccination. According to Faccioli-Martins et al. (2014) the vaccines developed do not yet provide adequate immunity. However, studies in Australia show a drastic reduction in the prevalence of the disease with vaccination.

In some countries (UK for example), the vaccine is not available, and control is based on identification and sacrifice of positive animals (Windsor, 2011).

Voigt, Baird, Munro, Murray and Brülisauer (2012) succeeded in eradicating CLA from a sheep flock on a Scottish farm through a “test and disposal” program with additional hygiene criteria; lasting approximately 22 months, the individuals were tested three times at monthly intervals with ELISA, with western blot to eliminate false positives. The study confirmed the efficacy of ELISA as a diagnostic tool, as it identifies clinical and subclinical cases. Although they have been successful in eliminating the disease, the authors did not report their cost. It should be noted that the strategy of identifying and sacrificing positive animals is advantageous only for flocks with low prevalence of the disease.

As indicated by Smith (2006), any strategy to reduce and eradicate a disease requires a prior study based on economic weightings and short and long term impact, analyzing “measures of effect” to arrive at a “cost-benefit” result. This result is achieved when the return is significantly higher than the investment, making the program financially viable.

This study highlights the relevance of this costly disease for goat farming. A significant damage to the industry is caused by CLA. Further studies assessing damage to beef and dairy herds, as well as reduced price of hide, should be conducted.

Conclusion

It is concluded that the prevalence of caseous lymphadenitis in goats slaughtered in Patos, Paraíba, a semi-arid region of Brazil, is high, and that the losses due to condemnations at slaughter were estimated at R\$ 4,540.33/kg. It should be noted that sex and age were associated with the prevalence of the disease. While the sex of the animals affected carcass and viscera weights and carcass yield, age affected live weight, carcass, organ, and viscera weights. Thus, it is essential to make goat farmers aware of the need to adopt control measures for the disease according to their situation, always considering the cost-benefit ratio.

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