ORIGINAL ARTICLE

http://dx.doi.org/10.21708/avb.2021.15.4.10025

Economic impact and epidemiological aspects of subclinical mastitis and caprine arthritis-encephalitis in the semiarid northeastern region of Brazil

Impacto econômico e aspectos epidemiológicos da mastite e artrite encefalite caprina na região semiárida do Nordeste Brasileiro

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ABSTRACT: Dairy activity in the semi-arid region has gained prominence due to its profit potential; however, there are still sanitary problems that result in significant economic impact. Thus, this study aimed to assess the economic impact and to conduct an epidemiological study of caprine arthritis-encephalitis (CAE) and subclinical mastitis in dairy goat herds of the semi-arid northeastern region of Brazil. The study proceeded with the collection of blood (n = 351) and milk samples (n = 321) from 15 rural properties with up to 50 animals, risk factor assessment, economic profile analysis, and georeferencing of the properties. The blood serum obtained was subjected to the AGID test. The milk samples were cultured on blood agar, and the reading was performed 24 hours after incubation. Overall, 3.4% of the animals were seropositive for CAE, and 15.8% were diagnosed with subclinical mastitis. 71.95% of the positive animals belonged to properties with a semi-intensive rearing system, weekly cleaning of the facilities, and no pre- or post-dipping. Subclinical mastitis caused by the main agent *Staphylococcus* spp. was associated with the breed type of the animals, highlighting two risk factors: purebred animals (OR = 12.52) and the milking performed close the soil (OR = 18.07). A reduction of up to 35.34% was observed in the income of dairy properties, constituting a considerable economic impact. Due to these sanitary problems, the economic impact demonstrates the need for a sanitary management program focused on these infirmities.

KEYWORDS: Dairy production; Small ruminants; Health; Disease economy.

RESUMO: A atividade leiteira na região semiárida vem ganhando expressividade devido seu potencial lucrativo, no entanto, ainda existem problemas sanitários que ocasionam de grande impacto econômico. Assim, objetivou-se dimensionar o impacto econômico e realizar o estudo epidemiológico da artrite encefalite caprina (CAE) e mastite subclínica, nos rebanhos caprinos leiteiros do semiárido nordestino. A pesquisa seguiu-se com a coleta das amostras de sangue (n=351) e leite (n= 321), avaliação dos fatores de risco, análise do perfil econômico das propriedades e georreferenciamento. O soro sanguíneo obtido foi submetido ao teste de IDGA. As amostras de leite foram semeadas em ágar sangue e a leitura realizada 24 horas após incubação. No total, 3,4%, dos animais foram soropositivos para CAE e 15,8% diagnosticados com mastite subclínica. 71,95% dos animais positivos pertenciam a propriedades com sistema de criação semi-intensivo, limpeza das instalações semanalmente e sem realização de pré e pós *dipping*. A mastite subclínica causada pelo principal agente *Staphylococcus spp*. mostrou-se associada ao padrão racial dos animais, sendo observado dois fatores de risco: padrão racial puro (OR = 12,52) e ordenha no solo (OR = 18,07). A redução nas receitas das propriedades leiteiras foi de até 35,34%, portanto, um relevante impacto econômico. Pode-se constatar a circulação do vírus da CAE nas propriedades rurais visitadas, além da presença de patógenos causadores da mastite com importância na área da saúde pública. O impacto econômico gerado em função da presença desses problemas sanitários demonstra a necessidade da implantação de um programa de manejo sanitário com foco nessas enfermidades.

PALAVRAS-CHAVE: Produção leiteira; Pequenos ruminantes; Sanidade; Economia de doenças.

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Received: 28/11/2020. Accepted: 09/03/2021

INTRODUCTION

The states of Bahia and Pernambuco are the largest goat producers in Brazil, totaling 9 million heads (IBGE, 2017). However, poor handling conditions and zootechnical structures have a significant influence on the occurrence of health problems (GUILHERME et al., 2017).

Caprine Arthritis-Encephalitis (CAE) and mastitis are among the main sanitary problems affecting dairy goat herds. CAE is a multisystemic, infectious disease with a long incubation period and a chronic progressive course, showing significant economic importance. The main clinical signs of CAE are arthritis characterized by enlarged carpus, leading to locomotion problems in animals, severe mastitis with mammary gland nodules, and purulent pneumonia (PENIDO et al., 2017).

Mastitis, another relevant illness, is characterized by a multifactorial infection responsible for significant losses due to its control and treatment expenses. This disease affects dairy goat and sheep herds as an inflammation of the mammary gland, with the intensity of the disease being determined by the nature and virulence factors of bacteria or groups of bacteria, the resistance of the agent to antibiotics, and other host-related factors (GABLI et al., 2019). The most common pathogens related to intramammary infections in small ruminants that can cause clinical and subclinical mastitis are those of the genus *Staphylococcus* (OLECHNOWICZ; JAŚKOWSKI, 2014).

Studies associating mastitis with economic damage are mostly directed towards bovines. The economic impact caused by mastitis varies widely across properties, being directly associated with the importance given to disease control and prevention (HOGEVEEN; VAN DER VOORT, 2017; RUSHTON, 2017; VISSIO et al., 2015). The treatment with different antimicrobials implies high costs, especially at the beginning of treatment, being economically disadvantageous (STEENEVELD et al., 2011).

Aiming to support the creation of sanitary management programs in dairy properties, it is essential to investigate the impact and real epidemiological situation of CAE and the cases of mastitis in this region. Thus, this study aimed to determine the economic impact and the epidemiological aspects of CAE and mastitis in dairy goat herds in the semi-arid northeastern region of Brazil.

MATERIAL AND METHODS

The study began after the approval by the Ethics Committee on Animal and Human Experimentation (CEUA) of the Federal University of São Francisco Valley (UNIVASF), under the number 0002/130318. The study covered six municipalities located in the states of Pernambuco and Bahia (Petrolina, Lagoa Grande, and Santa Maria da Boa Vista-PE, in addition to Juazeiro and Curaçá, in Bahia). A non-probabilistic convenience sampling was adopted for properties with herds containing up to 50 animals, totaling 18 properties.

Blood was collected from 351 goats, most of which females, including breeders. Milk was collected from 321 dairy goats. All animals were over one year of age, and the predominant breeds were Brown Alpine, Brown Swiss, Saanen, Anglo Nubian, Toggenburg, and crossbreed animals. To search for anti-CAE antibodies, the samples were subjected to the Agar Gel Immunodiffusion test (AGID) using a kit from Biovetech® - Indústria e Comércio de Produtos Biotecnológicas Ltda. For milk culture, 10µl aliquots were taken from each milk sample using a calibrated loop and spread onto the quadrants of a blood agar plate plus 5% sheep blood. The isolated colonies were observed regarding their morphology, size, pigmentation, and the presence of hemolysis. The isolated microorganisms were observed under a microscope using smears stained by the Gram method. The catalase and coagulase tests were used for genus confirmation.

To study the risk factors associated with infection, a cross-sectional study was conducted using a questionnaire with questions regarding the breeder, the general characteristics of the property, such as species, breed (pure or mixed breed), management system (intensive, semi-intensive, or extensive), and sanitary aspects (frequency of cleaning of the facilities, milking place, pre- and post-dipping), in addition to issues related to technical assistance to the producer. The analysis of risk factors was performed in two stages, comprising univariate and multivariate analysis. In the first moment (univariate analysis), the variables associated with the presence of mastitis were studied. Each independent variable was crossed with the dependent variable (mammary gland infection), with each animal considered a sample unit. For the study of the variables associated with a CAE focus, the rural property was considered a sample unit, with the CAE focus as the dependent variable. The variables with a value of $p < 0.2$ using the chi-square test or Fisher's exact test (ZAR, 1999) were selected and used in the multivariate analysis, using the multiple logistic regression according to HOSMER & LEMESHOW (2000). The collinearity between the predictor variables was verified by correlation analysis; for the variables that showed strong collinearity (correlation coefficient ≥ 0.9), one of the two was excluded from the multiple analysis according to the biological plausibility (DOHOO et al., 1996). The significance level adopted in the multiple analysis was 5% using the SPSS 13.0 software for Windows.

The presence of CAE foci was correlated with the number of mastitis cases by Spearman's test, which assesses the correlation between two quantitative variables (ARNDT, 1999).

Regression analysis was employed for the economic assessment by considering the presence/absence of mastitis and the average milk production (L/day) per property. Furthermore, the simultaneous presence of mastitis and CAE foci was also considered, evaluating their impact on reducing the milk volume produced by the herd and the revenue from milk commercialization by the producer.

RESULTS AND DISCUSSION

The search for antibodies against the CAE virus revealed that 3.4% (12/351) of the animals were seropositive. The presence

of subclinical mastitis was observed in 15.8% (51/321) of the properties using a milk culture technique in which the *Staphylococcus* spp. and *Micrococcus* spp. bacteria were obtained from goat milk samples (Table 1). Subclinical mastitis occurs predominantly in small ruminant herds, with a prevalence between 5% and 30%, reaching high rates in certain management situations (CONTRERAS et al., 2007). The presence of subclinical mastitis varies widely among herds, compromising the income of the small rural producer. Poor hygiene, inadequate handling, and the non-separation of infected animals contribute to spreading mastitis in goat herds (ZHAO et al., 2015). The absence of mastitis cases in three herds is justified by the climatic conditions, which can act as a barrier to the disease since dry and sunny environments act by reducing the cases of subclinical mastitis in lactating goats (MEGERSA et al., 2010).

The agent identified in the study belongs to the genus *Staphylococcus*, one of the main causes of subclinical mastitis in goats, and promotes an increase in the somatic cell count (CCS), leading to decreased milk production (SALABERRY et al., 2016).

In the case of positive properties for subclinical mastitis, the presence of *Staphylococcus* spp. Bacteria, found in most samples, suggests contamination due to poor hygiene of the handler as well as environmental contamination by *Micrococcus* spp. These results come from uncontrolled properties regarding environmental hygiene, with simple facilities and less frequent or no pre- and post-dipping. Some goat breeding properties with cases of subclinical mastitis in the state of Bahia showed a greater predominance of *Staphylococcus* spp. in the milk samples, isolated in 91.7% of the samples (CAVALCANTE et al., 2013). A low frequency of seropositive animals was observed for CAE and also for mastitis. Most of the owners who participated in this study belonged to a local association, all of whom are considered small farmers. Those who had purchased animals of lower zootechnical potential dismissed the main ones, especially at the time of milking, with poor hygienic-sanitary facilities and conditions. Otherwise, those with a more homogeneous herd usually performed milking on a platform and used teat antisepsis techniques, justifying the lower percentage of positive animals under these circumstances. Figure 1 exhibits the spatial distribution of the properties with positive animals for the studied infirmities.

The negative status for CAE in most herds was possibly due to the acquisition of animals from properties in Bahia and Pernambuco, which have a low prevalence of the disease.

Table 1. Bacteria isolated from goat milk samples collected from dairy goat herds in the micro-region of Juazeiro-BA and Petrolina-PE.

Microorganisms	N°	%
Staphylococcus spp.	23	76.7%
Micrococcus spp.	6	20.0%
Corynebacterium spp.	1	3.3%

Another hypothesis is the low viral, which becomes an obstacle for diagnosis by the AGID test (ANDRÉS et al., 2013). The genetic factors of the host can also influence the efficiency of the immune response, controlling the viral load of these lentiviruses (CARDINAUX et al., 2013).

In this study, there was no correlation between CAE foci and the presence of mastitis, despite the significant reduction in milk production. This result corroborates a study that investigated changes in milk and blood cells of dairy goats with natural CAEV infection, verifying no dysfunction of these cells as well as no greater susceptibility of the goat herd to secondary diseases (SANTOS et al., 2012).

The socio-economic assessment showed that 70% of breeders belong to local associations or cooperatives and have already received some goat farming training. Regarding the characteristics of the properties, 80% had a weekly cleaning frequency. The health management variable showed a mortality rate below 10% in properties with a semi-intensive farming system. Of the properties visited, 60% are formed by goats from neighboring properties located in the same state, most of which quarantine and vaccinate animals before introducing them into the herd, although without performing examinations.

One of the main factors for the presence of the infection was the cleaning frequency of the facilities. Cleaning was carried out weekly in 80.68% of the properties. The pre- and post-dipping preventive technique was not performed at the time of milking, resulting in a percentage of 80.04% of positive animals for mastitis. On the other hand, the properties that performed quarantine showed a lower percentage of positive animals than those who did not employ the same procedure or due to diseases (67.76%). The sanitary practices of preventive disease management contribute positively to reduce the number of pathogens in the livestock, especially those directed towards the proper hygiene of the environment and pre- and post-milking antisepsis.

In the univariate analysis, an association was observed between the presence of the disease and the lack of technical assistance, with a higher percentage of positive animals in the properties that were not assisted by a veterinarian (86.04%). The absence of qualified technical assistance is a relevant factor for maintaining the health status of the herds. Thus, once breeders do not receive proper technical instruction, the number of sanitary problems increases (Table 2).

This study showed that no variable constituted a risk factor for CAE. In the multivariate analysis, the breed type and milking place variables were risk factors for mastitis (Table 3). Regarding the breed, this result occurs because purebred animals show greater milk production, being more susceptible to mastitis. Regarding the milking place, the milking performed close to the soil increases the number of animals with mastitis. The microorganisms present in the soil constitute an important cause of the disease, being mainly responsible for environmental mastitis, which is caused by relevant pathogens such as bacteria of the family Enterobacteriaceae.

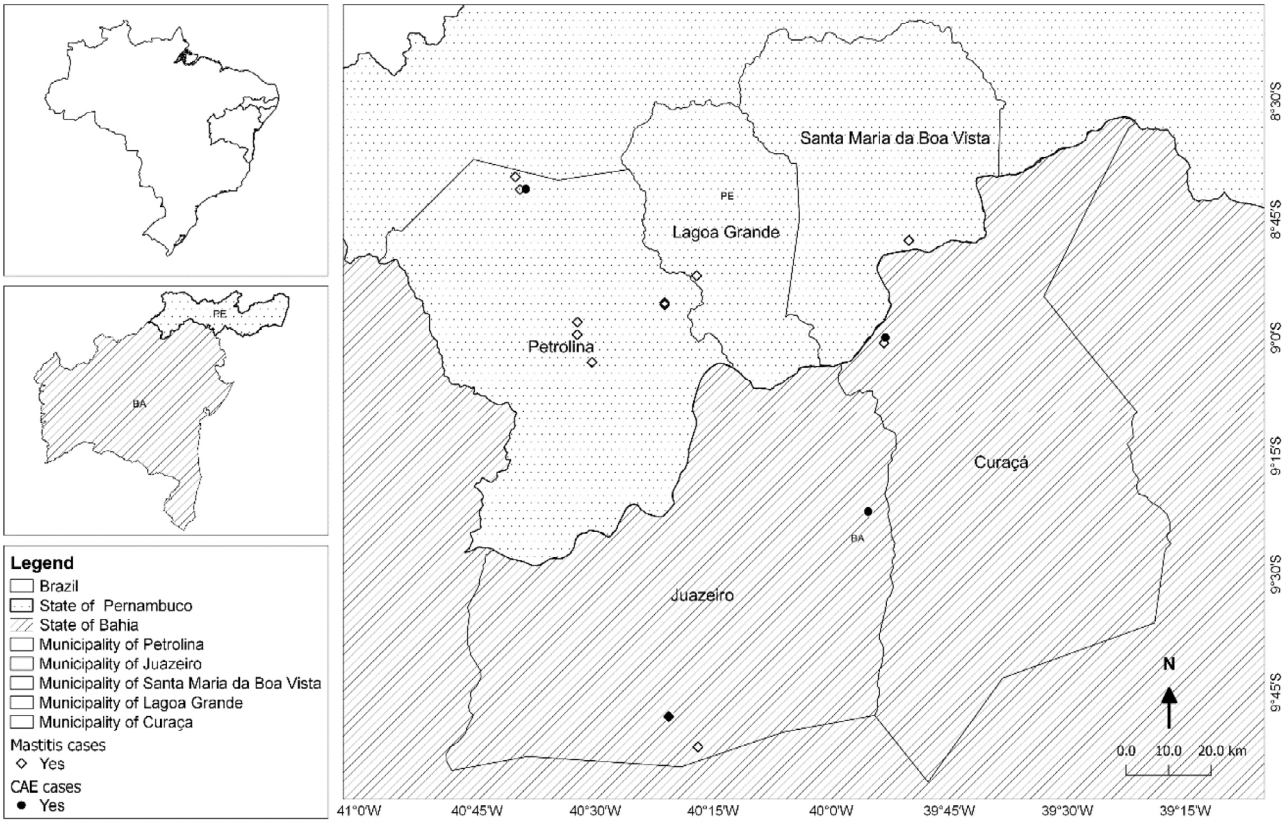

Figure 1. Georeferencing of goat farming properties with positive cases of CAE and mastitis.

Table 2. Univariate analysis of the management variables associated with mastitis in small rural properties in the semi-arid northeastern region of Brazil, 2019.

Variable	N° of animals	Positive (%)	P
Technical Assistance			
No	215	185 (86.04)	0.000*
Yes	103	62 (60.19)	
Breed type			
Crossbred	112	53 (47.32)	0.000*
Pure	209	194 (92.82)	
Management system			
Intensive	75	70 (93.33)	0.000*
Semi-intensive	246	177 (71.95)	
Milking place			
Soil	115	110 (95.65)	0.000*
Platform	206	137 (66.50)	
Pre/post dipping			
No	188	158 (84.04)	0.000*
Yes	133	89 (66.92)	
Cleaning frequency			
Daily	80	80 (100.00)	0.000*
Weekly	207	167 (80.68)	
Monthly	34	0 (0.00)	
Quarantine			
No	107	102 (95.33)	0.000*
Yes	214	145 (67.76)	

Table 3. Risk factors associated with mastitis in small rural properties in the semi-arid northeastern region of Brazil, 2019.

Status/ properties	Milk production (L*/animal/day)	Value (L/R$)	Economic impact (income reduction)
Mastitis		2,00	
Negative	1.95	-	-
Positive	0.97	-	35.34%
Mastitis and CAE			
Negative	1.40	-	-
Positive	1.06	-	24.29%

*L: Liters

Regarding the breed type, the goats considered purebred and, therefore, with a higher dairy potential were more likely to develop the disease (OR = 12.52). Goats that show high milk yields are less resistant to intramammary infections, especially in times of climatic variation (AKTER et al., 2020).

The economic analysis showed that milk production was lower in herds with mastitis (R2 = 0.7315; p <0.0178). On the other hand, in the analysis in which milk production was observed under the simultaneous presence of both diseases, there was no statistically significant difference despite the drop in milk production (Table 4).

In this study, mastitis brought economic losses equivalent to 35.34% in the income of small rural producers. These losses

Table 4. Economic impact of mastitis and CAE on rural properties in the semi-arid northeastern region of Brazil, 2019.

Risck factor	Regression coefficient	Standard Error	Odds ratio	CI 95%	P
Purebred animals	2.527	0.669	12.52	3.37 – 46.46	0.0002
Milking place (soil)	-2.894	0.669	18.07	0.01 – 0.21	<0.0001

*CI: Confidence interval

are due to the reduction in milk production, costs with treatment, and dismissal of animals. The high economic impact demonstrates the need to raise awareness among breeders regarding the economic relevance of the disease, requiring the involvement of the several participants of the goat milk production chain in order to mitigate the effects of the disease.

This study also revealed that there was no sign of CAE in the animals of the visited properties, and most breeders are unaware of the signs of Caprine Arthritis Encephalitis and its impact on the herd. These findings corroborate a study that reports the lack of data on the presence and absence of clinical signs in small ruminant herds of the region, influencing this unawareness (MICHIELS et al., 2018).

CONCLUSIONS

The study results demonstrate the circulation pathogens of relevance to the production chain of dairy goats in the targeted region. The economic impact due to these agents demonstrates the need to establish a sanitary management program focused on these infirmities, requiring support from public institutions to raise awareness among breeders regarding the importance of prophylactic practices in the sanitary management of the herds.

ACKNOWLEDGMENTS

To the Science and Technology Support Foundation of the State of Pernambuco, for the financial support.

REFERENCES

AKTER, S. et al. Prevalence, etiology and risk factors of subclinical mastitis in goats in Bangladesh. **Small Ruminant Research**, v. 184, p. 1-6, 2020.

ANDRÉS, X. et al. An insight into a combination of ELISA strategies to diagnose small ruminant lentivirus infections. **Veterinary Immunology and Immunopathology**, v. 152, p. 277-288, 2013.

ARNDT, S. et al. Correlating and predicting psychiatric symptom ratings: Spearman's r versus Kendall's tau correlation. **Journal of Psychiatric Research**, v. 33, n. 2, p. 97-104, 1999.

CARDINAUX, L. et al. Virological and phylogenetic characterization of attenuated small ruminant lentivirus isolates eluding efficient serological detection. **Veteterinary Microbiology**, v. 162, p. 572-581, 2013.

CAVALCANTE, M. P. et al. Bactérias envolvidas nas mastites subclínicas de cabra da região de Salvador, Bahia. **Arquivos do Instituto Biológico**, v.80, n. 1, p. 19-26, 2013.

CONTRERAS, A. et al. Mastitis in small ruminants. **Small Ruminant Research**, v. 68, p. 145-153, 2007.

DOHOO, I. R. et al. An overview of techniques for dealing with large numbers of independent variables in epidemiologic studies. **Preventive Veterinary Medicine**, v. 29, p. 221-239, 1996.

GABLI, Z. et al. Prevalence of mastitis in dairy goat farms in Eastern Algeria. **Veterinary World**, v. 12, p. 1563-1572, 2019.

GUILHERME, R. F. et al. Estudo sorológico da infecção por lentivírus em caprinos e ovinos abatidos no Estado da Paraíba, semiárido do Nordeste Brasileiro. **Semina: Ciências Agrárias**, v. 38, n. 3, p. 1651-1656, 2017.

HOGEVEEN, H., VAN DER VOORT, M. Assessing the economic impact of an endemic disease: the case of mastitis. **Revue Scientifique Et Technique-Office International Des Epizooties**, v. 36, n. 1, p. 217-226, 2017.

HOSMER, D. W., LEMESHOW, S. **Applied logistic regression.** New York: John Wiley and Sons, 2000. 375p.

IBGE. Instituto Brasileiro de Geografia e Estatística. **Censo Agropecuário 2017.** Disponível em: <https:/censos.ibge.gov.br/agro/2017/templates/censo_agro/resultadosagro/pecuaria.html?localidade=0&tema=75662>. Acesso em 07 Out. 2020.

MEGERSA, B. et al. Occurrence of mastitis and associated risk factors in lactating goats under pastoral management in Borana, Southern Ethiopia. **Tropical Animal Health and Production**, v. 42, p. 1249-1255, 2016.

MICHIELS, A. R. et al. Seroprevalence and risk factors related to small ruminant lentivirus infections in Belgian sheep and goats. **Preventive Veterinary Medicine**, v. 151, 2018.

OLECHNOWICZ, J.; JAŚKOWSKI, J. M. Mastitis in small ruminants. **Medycyna Weterynaryjna**, v. 70, p. 67-72, 2014.

PENIDO, P. M. P. N. et al. Ocorrência do vírus da artrite encefalite caprina (CAEV) em cabras leiteiras produzidas em sistema intensivo confinado no estado de Minas Gerais. **Pesquisa Veterinária Brasileira**, v. 37, n. 6, p. 577-581, 2017.

RUSHTON, J. Introduction Can economics be better used in animal health? **Revue Scientifique Et Technique-Office International Des Epizooties**, v. 36, n. 1, p. 17-21, 2017.

SALABERRY, S. R. S. et al. Análise microbiológica e perfil de sensibilidade do *Staphylococcus* spp. em mastite subclínica de caprinos leiteiros. **Arquivo Brasileiro de Medicina Veterinária e Zootecnia**, v. 68, n. 2, p. 336-344, 2016.

SANTOS, R. et al. Ocorrência de lentivírus de pequenos ruminantes no semiárido baiano e perfil da caprino/ovinocultura na região. **Ciência Animal Brasileira**, v. 13, n. 4, p. 494-503, 2012.

STEENEVELD, W. Cow-specific treatment of clinical mastitis: An economic approach. **Journal of Dairy Science**, v. 94, n. 1, 2011.

VISSIO, C. et al. Pérdidas productivas y económicas diarias ocasionadas por la mastitis y erogaciones derivadas de su control en establecimientos lecheros de Córdoba, Argentina. **Archives Medicina Veteterinaria**, n. 47, p. 7-14, 2015.

ZAR, J.H. **Biostatistical Analysis**. 4. ed. Prentice Hall, Upper Saddle River, 1999.

ZHAO, Y. et al. Prevalence and pathogens of subclinical mastitis in dairy goats in China. **Tropical Animal Health and Production**, v. 47, p. 429–435, 2015.