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Epidemiological survey and risk factors associated with hydrometra in dairy goat herds

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ABSTRACT

The aim of this study was to investigate epidemiological features of hydrometra in dairy goats. A cross-sectional study was carried out with 1,604 dairy goats from 21 farms in the Southeastern region of Brazil. Goats were examined by transrectal ultrasound (US) in order to determine the prevalence of hydrometra. To survey risk factors, it was applied an epidemiological questionnaire with questions about general farm characteristics, technological resources, goat performance records, and the management of reproduction, health, and nutrition. The prevalence of hydrometra was 9.2% (147/1,604). The variables associated with hydrometra in the univariate analysis were: age (P = 0.012); Saanen breed (P = 0.003); hormonal induced estrus (P = 0.0029); size of the herd (P = 0.0014); production system (P = 0.0080); duration of lactation (P = 0.0166); presence of dogs and/or cats in the herd (P = 0.0306); dogs and/or cats eating placenta or fetal remains (P = 0.0035); CAEV control (P = 0.0012) and absence of veterinary medical assistance (P < 0.00001). In the multivariate analysis, the variables that remained associated with hydrometra independently of the others were: age (P = 0.0003); breed (P = 0.006) [Saanen (P = 0.0725) CI 95%: 4.57 (0.87–24.05)], hormonal induced estrus (P = 0.0157) [CI 95%: 2.13 (1.15–3.93)], size of the herd (P = 0.004) [From 150 to 199 animals (P = 0.0367) CI 95%: 1.98 (1.04–3.76)], and presence of dogs and/or cats in the herd (P = 0.033) [CI 95%: 1.59 (1.03–2.43)]. Thus, the retention of older goats in reproductive activity must be re-evaluated for its relative merits and risks, Saanen goats must be mated according to the technical instructions of the Dairy Goat Breeding Program (Capragene®), and hormonal treatment for estrus induction must be used only if necessary. In larger herds, individual goats must receive attention beyond the data record of each animal. Finally, the presence of dogs and/or cats among goats should be avoided.

1. Introduction

Brazil is a country of continental dimensions, with notable variations in topography, climate, and consequently, in the availability of food. Almost 10 million goats are raised in the country (FAOSTAT, 2016). Goat milk production is concentrated in two diverse regions: the northeast and the southeast, with 93% and 2% of the Brazilian herd, respectively (Souza et al., 2017). Despite occupying a small part (10%) of the Brazilian territory (IBGE, 2015), the southeast is a reference in goat milk production, accounting for around 25% of the national total (Lopes et al., 2012). In 2005, the Dairy Goat Breeding Program - Capragene® (Facó et al., 2011) implemented the Progeny Test and official milk record keeping (Lôbo et al., 2017). Besides increasing the productivity of dairy goats, Capragene® contributed the development and use of artificial insemination (AI) (Fonseca et al., 2017a,b) and the US for the diagnosis of pregnancy.

Hydrometra or pseudopregnancy in the goat is a pathological condition characterized by the accumulation of aseptic fluid in the uterine lumen due to the persistence of one or more corpus luteum (Pieterse and Taverne, 1986). The disease may occur in goats regardless of mating or conception. There are no clear clinical manifestations accompanying hydrometra and due to the absence of pus in the uterine lumen and the normal number of inflammatory cells in the endometrium it can't be considered as an inflammatory disease (Wittek

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et al., 1998). Usually, the affected goats present an anestrous condition and the distension of the abdomen similar to what occurs during pregnancy (Martel, 2001). The US evaluation of the southeastern dairy goat herds identified hydrometra as the most frequent reproductive disorder (Maia et al., 2018a). Considered one of the major causes of subfertility and/or infertility in dairy goats, hydrometra may be responsible for great economic losses in commercial breeding (Hesselink, 1993). Although the exact cause of the disease is not known (Pieterse and Taverne, 1986), some factors have known associations with its occurrence. Among these are gestational loss (Humblot et al., 1995; Wittek et al., 1998; Chemineau, 1999), genetic influence (Hesselink and Elving, 1996), synchronization and induction of estrus with progestogens (Mialot et al., 1991; Duquesnel et al., 1992; Matthews, 2009), prolonged lactation (Matthews, 2009), systems of production (Martel, 2001), breeds (Santa Rosa et al., 1986), nutritional management (Brice et al., 2003), and age (Mialot, 1991; Duquesnel et al., 1992; Hesselink, 1993; Wittek et al., 1998; Almubarak et al., 2018). This was the first study performed in dairy goat herds in Southeastern Brazil to conduct an epidemiological survey with the aim to determine the prevalence of hydrometra and investigate the odds of specific risk factors associated with its occurrence.

2. Materials and methods

2.1. Ethics and animal care

All the study procedures were conducted under the principles of the Brazilian Society of Laboratory Animal Science, which regulates conditions for experiments involving animals. The Animal Care Committee of the Universidade Federal Fluminense approved the study design (protocol number #678/2015).

2.2. Design and study population

A cross-sectional observational study was carried out with goats from a total of 21 commercial dairy farms in order to determine the prevalence of and possible risk factors for hydrometra in the Southeastern region of Brazil. The study population comprehended the herds associated to Capragene® program (population size = 2,170), with at least one herd per state of southeast region of Brazil. The animals included in this study were goats in reproductive age (> eight months). In each farm, US exams were performed in all goats in this condition. It was used a sample proportion of 20%, based in previous results that showed a prevalence ranging from 12.4% to 30.4% in southeast (Souza et al., 2013) and northeast (Lopes Junior et al., 2004) of Brazil, respectively. It was also chosen a margin of error of 1% and confidence level of 95%, and thus the recommended sample size was 1,604. US evaluations were performed on 1,604 goats of Saanen (77.0%, or 1,235 of 1,604), Alpine (14.2%, or 227 of 1,604), Toggenburg (8.1%, or 130 of 1,604), and other breeds [Anglo-Nubian and crossbreeds (0.7%, or 12 of 1,604)], ranging from one to ten years old.

2.3. Period, location, and study conditions

Between the months of January and December of 2015, commercial dairy goat herds located in the Southeastern region of Brazil (states of Espírito Santo, Minas Gerais, Rio de Janeiro and São Paulo) were visited once.

On 18 of the farms, goats were raised in an intensive production system, confined in group pens, and fed with chopped *Pennisetum purpureum* forage, Tifton hay, or corn silage. On the three remaining farms, the production system was semi-intensive with access to pasture.

2.4. Ultrasonography

The reproductive tract of each goat was examined once by the same operator using B-mode real-time ultrasound scanner (Mindray®; DP330 Vet, Shenzhen, China) equipped with a 5 MHz linear transrectal transducer. To facilitate its use in small ruminants, the transducer was taped to a PVC tube (Souza, et al 2013). Ultrasound scanning was done while the goats were well restrained on the standing position. 10 mL of carboxymethycellulose gel (Carbogel 105 UTL®; Carbogel Indústria e Comércio LTDA, São Paulo, Brazil) was deposited into the goat's rectum for lubrication and to ensure good contact between the transducer and the rectal wall.

For the goats that have been previously mated, the US evaluations were performed at least after 30 days of mating. At this time, it was possible to see the conceptus and its heartbeat. If there was no reproductive data and US scanning was suggestive of early pregnancy or early hydrometra (Maia et al., 2018b), the female was not included in the survey. In this case it was recommended to the farmer to wait 30 days and repeat the exam.

After visualization of the urinary bladder, imaging of the uterus and ovaries was performed to evaluate reproductive soundness. In cases of hydrometra, depending on the amount of fluid present in the uterus, it was possible to visualize the ovaries with the corpus luteum or even follicular cysts (Souza et al., 2013). Hydrometra was characterized by large fluid filled compartments (anechoic areas) separated by thin tissue walls. Sometimes, it was less developed, being the final diagnosis based on the absence of fetuses, membranes, and placentomes (Pieterse and Taverne, 1986; Hesselink, 1993; Maia et al., 2018b).

2.5. Data collection and main study variables

For the survey of the risk factors on each farm, the same interviewer applied an epidemiological questionnaire with 59 close-ended questions and 27 open-ended questions about general farm characteristics, technological resources, goat performance records, and the management of reproduction, health, and nutrition.

The dependent variable of the study was defined as the presence or absence of hydrometra during the US evaluation. The risk factors were grouped into three hierarchical levels (Victora et al., 1997) according to their relativity: i) Distal level variables (from records of performance, health, and nutritional management) included the size of the herd, production system, average daily milk production, average duration of lactation, presence of dogs and/or cats in the herd, dogs and/or cats eating placenta or fetal remains, caprine arthritis encephalitis virus (CAEV) control, constant veterinary medical care, and frequently altered diet. ii) Middle level variables (reproductive management) included synchronization of estrus, any kind of induction of estrus, induction of estrus with light program, induction of estrus with hormonal protocols, repetition of estrus, and occurrence of abortion. iii) Proximal level variables (individual) included age and breed.

2.6. Data management and statistical analysis

Data were managed with Epi Info version 3.5.3 statistical software and analyzed using SPSS version 20. A univariate logistic regression analysis was done using chi square test. A level of 5% was considered significant. Any variable that met the initial criteria of $P \leq 0.2$ in the univariate analysis was included in the multivariate analysis. A backward stepwise method was used to reach a satisfactory level of fit. Crude and adjusted Odd Ratios (OR) and 95% confidence intervals (CI) were calculated and goodness-of-fit was assessed by Hosmer and Lemeshow's test.

3. Results

3.1. Descriptive analysis

Among the 1,604 goats examined, 147 (9.2%, CI 95%: 7.78 to 10.61) were diagnosed with hydrometra. Of the 21 herds evaluated,

Table 1
Univariate analysis of variables related to the occurrence of hydrometra in dairy goats from 21 herds in the Southeastern region of Brazil.

Hierarchical level	Variables	Absolute Frequency (n)	Relative Frequency (%)	Odds Ratio (CI 95%)*	Chi-square	P-value
PROXIMAL LEVEL						
	Age			1.14	**10.558**	**0.0012**
	Breed				**24.083**	**< 0.0001**
	Toggenburg and others**	142	8.9	1		
	Alpine	227	14.2	1.47 (0.37 – 5.79)		0.784
	Saanen	1235	77.0	5.78 (1.81 – 18.39)		0.0030
MIDDLE LEVEL						
	Use of synchronization of estrus				**1.032**	**0.3097**
	Yes	529	33.0	1		
	No	1075	67.0	1.20 (0.84 – 1.70)		0.3102
	Use of induction of estrus				**1.484**	**0.2230**
	Yes	1556	97.0	2.36 (0.56 – 9.83)		0.2370
	No	48	3.0	1		
	Use of artificial light regimens to induce estrus				**1.917**	**0.1662**
	Yes	1054	65.7	1		
	No	550	34.3	1.27 (0.90 – 1.81)		0.1670
	Use of hormonal protocols to induce estrus				**8.877**	**0.0029**
	Yes	1201	74.9	2.01 (1.26 – 3.21)		0.0034
	No	403	25.1	1		
	Repetition of estrus				**2.412**	**0.1204**
	Yes	1250	77.9	1.42 (0.90 – 2.22)		0.1220
	No	354	22.1	1		
	Occurrence of abortion				**5.120**	**0.0773**
	Rare	1038	64.7	1		
	Frequent	138	8.6	1.29 (0.71 – 2.35)		0.3899
	During lambing season	428	26.7	1.52 (1.05 – 2.20)		0.0263
DISTAL LEVEL						
	Size of the herd				**15.536**	**0.0014**
	From 50 to 99 animals	300	18.7	1 (0.49 – 2.3)		
	From 100 to 149 animals	240	15.0	0.93 (0.40 – 2.01)		0.8622
	From 150 to 199 animals	562	35.0	2.35 (1.24 – 4.45)		0.0084
	More than 200 animals	502	31.3	2.43 (1.27 – 4.62)		0.00067
	Production system				**9.647**	**0.0080**
	Intensive	1145	71.4	1		
	Semi-intensive	132	8.2	1.28 (0.69 -2.36)		0.4281
	Mixed (intensive and semi-intensive)	327	20.4	1.82 (1.24 – 2.67)		0.0022
	Milk production* **				**0.828**	**0.6609**
	From 2.0 to 2.5 kg/day	495	30.9	1.20 (0.80 – 1.81)		0.3720
	From 2.6 to 3.2 kg/day	598	37.3	1		
	From 3.3 to 4.0 kg/day	511	31.9	1.06 (0.69 – 1.61)		0.7809
	Duration of lactation ***				**5.734**	**0.0166**
	Up to 10 months	1220	76.1	1		
	Over 10 months	384	23.9	1.56 (1.08 – 2.25)		0.0173
	Presence of dogs and/or cats in the herd				**4.675**	**0.0306**
	Yes	813	50.7	1.46 (1.03 – 2.06)		0.0313
	No	791	49.3	1		
	Dogs and/or cats eating placenta or fetal remains				**8.515**	**0.0035**
	Yes	744	46.4	1.66 (1.17 – 2.33)		0.0038
	No	860	53.6	1		
	Control of CAEV				**10.447**	**0.0012**
	Laboratory tests	601	37.5	1		
	Prophylactic management	1003	62.5	1.87 (1.27 – 2.76)		0.0014
	Constant veterinary medical assistance				**18.404**	**< 0.0001**
	Yes	600	37.4	1		
	No	1004	62.6	2.39 (1.59 – 3.61)		< 0.00001
	Change the composition of the diet frequently				**2.888**	**0.0892**
	Yes	240	15.0	1		
	No	1364	85.0	1.45 (0.94 – 2.23)		0.0907

* CI = Confidence interval.
** Anglo-Nubian and crossbreeds.
*** Average of the herd.

only two did not present any females with hydrometra. The disease prevalence within each herd ranged from 0 to 55.6%. The mean age of goats with hydrometra was 3.8 ± 1.8 years old.

The farms had between 2.4 and 290.0 ha, and 11.0% of the farms had dairy goat production as the unique activity. Most farms reared goats in pens with slatted floors (68.7%) in a confined intensive production system (71.4%), predominantly in herds that had between 150 and 199 (35.0%) or more than 200 animals (31.3%). On two farms with less than 50 animals, no goats with hydrometra were diagnosed; however, one of the farmers reported having already identified more than one case of the disease in US evaluations prior to our visit. On 94.6% of the farms, the milk was collected in a milking parlor. The procedure was done by hand milking (12.7%), a bucket portable milking system (41.9%), or a closed milking machine (45.4%). On 86.5% of the farms, the milk was stored in bulk tanks. Most of the goats were separated in collective pens according to milk production (68.3%). Among herds, there were large variations in the mean daily milk production, from 2.0 kg/day (9.8%) to 4.0 kg/day (1.1%), and in

the lactation duration, from six to eight months (18.1%) to 36 months (5.2%), as reported by the farmers.

Regarding reproductive management, there was predominance in hand mating (the female is taken to one previously-determined male - 80.6%) over batch mating (the male is placed into the pen with the females - 5.6%) or both types (13.8%). Nevertheless, due to the participation in the Progeny Test of Capragene® (85.2%), the use of AI was reported by 87.6% of the farmers. Inbred mattings and the existence of hornless male or female goats were verified in 11.5% and 57.9% of the herds, respectively. During the breeding season, some farmers synchronized the estrous cycle of females (33.0%). In the non-breeding season, the producers used estrus induction techniques (97.0%) to guarantee milk production in the off season. Some farmers reported choosing to use the artificial light regimens to induce estrus (65.7%) as a more natural alternative. However, if goats did not respond to this procedure, they ended up using the hormonal cocktail protocols. In this way, the use of hormone was verified in 74.9% of the herds as the main choice or the default in case of need. Almost 80% of the herds presented problems of recurrence of estrus after breeding, and all the farmers related the occurrence of abortions, with differences only in the frequency of the event.

In relation to health management, most herds (97.6%) were vaccinated against one or more diseases: clostridial diseases (77.8%), caseous lymphadenitis (26.1%), rabies (12.8%), and leptospirosis (8.1%). In some farms, the control of CAEV was done with laboratory tests (37.5%) and prophylactic management (*i.e.,* treatment of colostrum and milk, discarding or disinfecting fomites). In order to eliminate the rats and protect the goats, dogs and/or cats were observed in some herds (50.7%). Constant veterinary medical assistance was found in 37.4% of the herds. The verification of dogs and/or cats eating placenta or fetal remains was confirmed in 46.4% of the farms. Some farms used of drugs for internal (91.3%) and external (69.4%) parasite control, as well as blowtorch (77.6%) and lime (58.0%) to maintain a clean environment.

Regarding nutritional management, 74.3% of the farms had the feed calculated by an animal science professional or veterinarian. Concentrate was found in all herds, especially since the majority manufactured it (73.1%). Some farmers offered more than one type of roughage such as *Pennisetum purpureum* (83.5%), corn silage (80.7%) and Tifton hay (52.2%), in addition to mineralized salt for goats (95.6%) on salt feeders or mixed into the concentrate. Due to dry periods or difficulties in buying inputs, some farmers reported a change in the composition of the diet (15.0%) throughout the year. The water supplied to animals came predominantly from springs (66.3%), with a storage reservoir that prevented access by other animals.

3.2. Univariate regression analysis

The variables were compared, tested, and then divided by hierarchical levels as shown in Table 1. The variables associated with hydrometra in the univariate analysis were: age, Saanen breed, use of hormonal protocols to induce estrus, size of the herd, production system, duration of lactation, presence of dogs and/or cats in the herd, dogs and/or cats eating placenta or fetal remains, CAEV control and absence of veterinary medical assistance.

3.3. Multivariate regression analysis

Final multivariate regression analysis is presented in Table 2. The following variables remained associated with hydrometra independently of the others: age; Saanen breed, use of hormonal protocols to induce estrus, size of the herd and presence of dogs and/or cats in the herd.

4. Discussion

To the best of the author's knowledge this was the first epidemiological survey about risk factors associated with hydrometra to be done in Brazil. This study established a profile of the dairy goat herds located in the southeast region of the country. The technological resources found on the farms were compatible with the intensification of the production system that is predominant in this region (Lôbo et al., 2010). To maintain quality and homogeneous milk production throughout the year, goats are subjected to the induction of estrus, since all farms reported that reproduction otherwise was seasonal. As a negative factor, the lack of constant veterinary assistance on most farms may be responsible for some errors of health, nutrition, and reproduction.

In the present study, the prevalence of hydrometra was 9.2%. Our results were similar to Santa Rosa et al. (1986) and Hesselink (1993) who reported a prevalence of 9.7% in native and crossbred goats examined in the slaughterhouses of northeast region of Brazil and 9% in Saanen goats in Netherlands, respectively. A prevalence of 10% and 10.6% were also reported by Desire et al. (2018) in crossbred of original breeds (Alpine, Saanen, Toggenburg) in the United Kingdom and by Almubarak et al. (2018) in different goat breeds in Khartoum State, Sudan, respectively. Lopes Júnior et al. (2004) found a prevalence of 30.4% in Saanen goats raised in the northeast region of Brazil. All these reports endorse the need for routine US assessments to diagnose hydrometra, since this disease causes economic losses in commercial dairy goat farms. These US evaluations must be done before and after the breeding season to verify reproductive tract disorders and to confirm pregnancy ensuring an increase in the reproductive and productive efficiency of the herds. According to the data obtained in our study, the average age of diseased goats was 3.8 ± 1.8 years, similar to 2.9 ± 1.6 years and 3.6 ± 1.0 years, reported in studies conducted in France and the Northeastern region of Brazil, respectively (Mialot et al., 1991; Salles and Araújo, 2008). Hesselink (1993) reported that disease was more prevalent in goats between six and eleven years old (32.4%) than in goats between one and five years old (10.4%), and older goats presented a significantly higher occurrence than nulliparous goats (18.3% *vs* 1.0%). Similarly, Desire et al. (2018) found fewer records of hydrometra in nulliparous goats. In the farms visited during our study, we noticed that some farmers insisted on retaining older goats (more than five lactations) in reproductive activity for the perpetuation of their genetics. Now the Capragene® is performing improvement in herd genetics (Lôbo et al., 2017), this concept is being modified, and most farmers keep herds goats only in age ranges that can still achieve good milk production. Thus, with the decrease of the average age of females, there should be a decrease in the occurrence of the disease.

In the present study, five factors associated with the presence of hydrometra in the univariate analysis did not remain after the multivariate analysis but should be carefully observed. One of these factors is the occurrence of abortion mainly during the lambing season ($P = 0.026$). Wittek et al. (1998) reported that 17 of 143 goats were diagnosed with embryonic or fetal remnants by US. After laparotomy, a dead fetus at a gestational age of about 40 days was removed from the uterus of a goat affected by hydrometra. According to Pugh (2002), several factors such as infectious agents (microorganisms), stress, nutritional deficiency, toxic plants and inappropriate use of drugs can be related to gestational loss in goats. Our findings also revealed that the production system was associated with hydrometra ($P = 0.008$). This is in agreement with Martel (2001) who reported that goats submitted to semi-intensive (15/158, 9.49%) had a higher incidence than goats raised in the intensive system (30/1202, 2.50%). Conversely, Almubarak et al. (2018) did not find any association ($P = 0.451$). According to Matthews (2009), the persistence of corpus luteum (that can lead to hydrometra) is particularly common after the second year of lactation without being mated. Desire et al. (2018) reported that hydrometra is associated with longer productive lifespan (regardless of

Table 2
Final multivariate regression analyses of variables associated to the occurrence of hydrometra in of 21 dairy goats herds from the Southeastern region of Brazil.

Hierarchical level	Variables	Odds Ratio (CI 95%)*	P-value
PROXIMAL LEVEL			
	Age	1.17 (1.07 – 1.28)	**0.0003**
	Breed		**0.006**
	Toggenburg and others	1	
	Alpine	1.53 (0.24 – 9.77)	0.6498
	Saanen	4.57 (0.87 – 24.05)	0.0725
MIDDLE LEVEL			
	Use of hormonal protocols to induce estrus		**0.0157**
	Yes	2.13 (1.15 – 3.93)	
	No	1	
DISTAL LEVEL			
	Size of the herd		**0.004**
	From 50 to 99 animals	1	
	From 100 to 149 animals	0.60 (0.26 – 1.36)	0.2212
	From 150 to 199 animals	1.98 (1.04 – 3.76)	0.0367
	More than 200 animals	1.63 (0.86 – 3.09)	0.1317
	Presence of dogs and/or cats in the herd		**0.033**
	Yes	1.59 (1.03 – 2.43)	
	No	1	

Teste de Hosmer and Lemeshow: 0.276; Cox & Snell R^2: 0.046; Nagelkerke R^2: 0.095.
* CI = Confidence interval.

milk yield). Similar to these observations, in the present study, lactation extended for over 10 months showed an association (P = 0.0173) with hydrometra. The following three risk factors associated with the disease are quite related to the health management of the herd. In fact, some farmers reported seeing dogs and cats eating goat's placenta (P = 0.0035), not controlling CAEV with laboratory examinations (P = 0.0012), and not having constant veterinary assistance (P < 0.00001). Although speculative, the change in these attitudes could contribute to the healthy status of the goats, besides increasing the individual monitoring of the animals.

The multivariate analysis verified an independent association between hydrometra and each of the following variables (P < 0.05): increase in age, the Saanen breed, induction of estrus with hormonal protocols, increase in herd size, and presence of dogs and/or cats in the herd. Among the proximal level variables, increase in age (P = 0.0003) and the Saanen breed (P = 0.006) were associated with the occurrence of hydrometra in this study. The chance of presenting with hydrometra increased 1.17 times per year (CI 95%: 1.07–1.28) relative to the chance the previous year. Our group has recently reported that three-year-old goats showed greater occurrence of hydrometra (P < 0.05) (Maia et al., 2018a). In relation to breed, Saanen goats showed a borderline association (P = 0.07) [CI 95%: 4.57 (0.87–24.05)] with hydrometra. The Saanen breed is known for its high milk production and persistence of lactation, and is therefore one of most popular breeds in the world of goat dairy production (Ribeiro, 1997). Hesselink and Elving (1996), studying Saanen goats verified genetic influences on the occurrence of hydrometra and suggested further researches. Lopes Júnior et al., 2004 determined that hydrometra was an important problem in Saanen goats raised in Northeast Brazil. Although Almubarak et al. (2018) did not find any association between breed and hydrometra they reported that the higher prevalence was found in Saanen goats and their crosses.

Among the middle level variables, only induction of estrus with hormonal protocols presented an association (P = 0.0157) with the occurrence of hydrometra, compared with herds without hormonal induction [(CI 95%: 2.13 (1.15–3.93)]. According to several authors, the synchronization and induction of estrus with progestogens (Mialot et al., 1991; Duquesnel et al., 1992; Humblot et al., 1995; Almubarak et al., 2018) play an important role in the development of the disease. On the other hand, Lopes Júnior et al. (2004) reported that the prevalence of hydrometra between synchronized and cyclic groups did not differ (33.3% compared to 28.6%). The present study verified that errors of reproductive management sometimes occurred with the inadequate use of gonadotrophins in the protocols of estrus induction. It has been reported that the repetitive use of eCG may cause a decrease in the fertility of goats (Baril et al., 1996; Hervé et al., 2004). When this happens, some farmers inadvertently increase the dose of eCG to obtain higher fertility rates, leading to other reproductive problems. In order to avoid the excessive use of drugs, farmers have been advised to adjust hormonal protocols and select more natural methods of synchronization and induction of estrus. In this way, with standardized protocols, future studies can make more reliable evaluations about hormonal influences in the occurrence of hydrometra.

The distal level variables that were associated with hydrometra in this study were the size of the herd (P = 0.004) and the presence of dogs and/or cats in the herd (P = 0.033). In multivariate analysis, the odds of hydrometra occurring were higher in the largest herds, *e.g.*, from 150 to 199 animals (CI 95%: 1.98 [1.04–3.76]). This association also was demonstrated in univariate analysis, in which a linear trend between herd size and hydrometra prevalence was verified (P = 0.0014). Various authors have related an increase in mortality of cows in dairy herds with an increase in herd size due to the use of hired labor and less attention spent on individual cows (Norgaard et al., 1999; Alvasen et al., 2012). On the other hand, Gieseke et al. (2016) reported that herd size did not directly affect the welfare status of dairy cows, though it was associated with frequency of vulvar discharge (P = 0.003). These diverging reports demonstrate the importance of attentive record-keeping of individual goats and their reproductive history, since hydrometra is reported as a silent disease because its symptoms are not easily observed and may be misattributed to pregnancy (Martel, 2001). Finally, the identification of the presence of dogs and cats in the herds as a risk factor, albeit speculative, demands a more detailed exploration of the possibility that hydrometra can be developed after the conceptus loss caused by an infectious disease transmitted by other species of animals that remain close to the goats. The causes of fetal death and resorption, abortion, or stillbirth in goat herds include *Toxoplasma gondii* (hosted by cats) and *Neospora caninum* (hosted by dogs) (Abu-Dalbouh et al., 2012; Moreno et al., 2012). These diseases have already been identified in several sheep and goat herds in Brazil (Silva et al., 2013; Topazio et al., 2014). In this case, serological tests could answer some questions related to reproductive failures, including those that involve hydrometra.

5. Conclusion

This study used US examinations to determine a 9.2% prevalence of hydrometra in goats in Southeastern Brazil. This prevalence demonstrates the importance of this reproductive disorder in the productive efficiency of the herds, since hydrometra is considered an important cause of subfertility and infertility in dairy goats. This study identified the following variables as risk factors related to the occurrence of hydrometra: increase in age, the Saanen breed, estrus induction with hormonal protocols, increase in herd size, and presence of dogs and/or cats in the herd. Thus, the retention of older goats in reproductive activity must be re-evaluated; goats (mainly of the Saanen bred) must be mated according to the recommendations of the Capragene® breeding program, and hormones must be used only as a last resort for the induction of estrus. In larger herds, individual goats must receive attention beyond the data record of each animal. Finally, the presence of dogs and/or cats among goats should be avoided.

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Declaration of Competing Interest

There are no conflicts of interest regarding authorship or publication of this article.

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