

Article

Epidemiological Insights into Haemonchosis from Necropsy Records of Small Ruminants in Northeast Brazil

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Abstract

The main pathological, epidemiological, and clinical findings of haemonchosis in goats and sheep in a semi-arid region of Northeast Brazil are described. Necropsy records conducted between January 2012 and December 2021 at the Animal Pathology Laboratory (APL) of the UFCG, were reviewed. In 2022, a prospective study monitored the necropsies performed on these species. In total, necropsies were conducted on 410 goats and 319 sheep, haemonchosis was observed in 50 (12%) goats and 49 (15%) sheep. For goats, females (45/50, 90%; $p \leq 0.05$), the age range of 13–35 months (25/50, 50%; $p \leq 0.05$), and crossbred animals (38/50, 76%; $p \leq 0.05$) were most affected. Both goat and sheep, respectively, raised in a semi-intensive system were more infected (41/50, 82%; 36/49, 76.5%; $p \leq 0.05$). The animals came from the States of Paraíba, Pernambuco, Ceará, and Rio Grande do Norte. The proportion of goats (32/50, 64%) and sheep (30/49, 61.2%) with a normal body condition score was significantly different ($p \leq 0.05$). The main pathological alterations ($p \leq 0.05$) were the mucosal and carcass paleness, and the presence of *H. contortus* specimens in the abomasum. Haemonchosis remains a significant parasitic disease affecting small ruminants in the semi-arid region of Northeast Brazil, leading to mortality and decreased production rates, posing substantial economic challenges that adversely impact goat and sheep farming.

Keywords: goats; sheep; parasitic disease; nematode; anemia



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1. Introduction

Sheep and goat farming plays a fundamental role in Brazilian livestock production, especially in semiarid regions such as the Northeast, contributing to food security and the local economy [1]. The region concentrates about 11.9 million goats and 20.5 million sheep, corresponding to 95% and 70% of the national herd, respectively [2]. These animals are well adapted to adverse conditions, being hardy, heat-tolerant, and efficient in feed and water use, thus providing economic and environmental benefits [3,4]. However, infection by gastrointestinal endoparasites remains the greatest obstacle to maintaining productivity in small ruminant farming systems, due to the significant economic losses associated with

reduced weight gain, decreased milk production and fertility, in addition to increased mortality and high costs of treatment, control and prophylaxis measures [5–7].

Among the endoparasites that affect small ruminants, *Haemonchus contortus* is particularly relevant, being the parasite that causes haemonchosis, which causes major economic losses in the livestock industry worldwide [8]. Haemonchosis mainly affects goats and sheep of all ages, causing severe anemia and hypoproteinemia. These changes are consequences of the hematophagous activity of parasites that feed on blood from the abomasum capillaries, resulting in clinical signs such as pale mucous membranes, subcutaneous and cavity edema [6,8,9]. In the semiarid region of the Northeast, the disease shows a seasonal pattern, with the highest incidence observed after the rainy period, due to the high temperature and humidity, which favor the persistence of infective larvae in pastures [10].

The main parasitic control method in small ruminants is the use of synthetic anthelmintics [11]. However, factors such as the frequency of treatments, sub-dosing, mass deworming, and the prolonged use of the same active ingredient have led to widespread anthelmintic resistance among parasite populations, especially to chemical groups such as imidazothiazoles, benzimidazoles, and macrocyclic lactones worldwide [12–14], including in the semiarid region of Northeast Brazil [15].

The disease represents the primary cause of mortality in small ruminants in various regions of Brazil [16–18]. Despite this relevance, there is a lack of studies based on necropsy records that characterize the pathological aspects of haemonchosis in animals from the semiarid region, which could provide valuable epidemiological insights into local mortality patterns and parasite dynamics.

Therefore, this study aimed to describe and analyze the main pathological findings of haemonchosis and their relationship with epidemiological and clinical information obtained from necropsied small ruminants in the semiarid region of Northeast Brazil. This approach provides practical information that may support regional parasite control programs and improve herd health management.

2. Materials and Methods

The necropsy archival records of 398 goats and 306 sheep at the Animal Pathology Laboratory (APL) of the Veterinary University Hospital at the Federal University of Campina Grande (UFCG), Patos, State of Paraíba, were reviewed for the period from January 2012 to December 2021. The inclusion criteria for the classification of haemonchosis were defined as the identification of *H. contortus* in the abomasum, along with the presence of characteristic clinical signs (e.g., anemia, pale mucous membranes, subcutaneous or cavity edema) and/or pathological lesions observed during necropsy. Epidemiological data (gender, age, breed, deworming, animal origin, breeding system, and herd size), clinical information (body condition score, presence of anorexia, apathy, emaciation, diarrhea, decubitus, dyspnea and/or paresis, and fur aspect), as well as pathological findings (presence of *H. contortus* on the abomasum, alterations like mucous and carcass paleness, pulmonary, subcutaneous, mesenteric and abomasal edema, hydropericardium, hydrothorax, ascites, atrophy of cardiac fat, abomasal ulcers, and concurrent parasitic infections) were collected from clinical and necropsy records. Cases were selected in which *H. contortus* were observed in the abomasum associated with clinical and pathological signs of the disease. The completeness and quality of the records were verified by checking for missing or inconsistent data; records lacking essential epidemiological, clinical, or pathological information were excluded from the analysis to ensure reliability.

Additionally, from January to December 2022, a prospective study was conducted, involving a thorough search, measurement, and classification of gastrointestinal nematode infections in small ruminants. During this period, 12 goats and 13 sheep referred to APL-

UFCG were necropsied for gastrointestinal nematode identification following the guidelines established by the World Association for the Advancement of Veterinary Parasitology (WAAVP) and described by Vercruysse et al. [19]. The gastrointestinal tract was divided into its anatomical segments (abomasum, small intestine, and large intestine), which were isolated and subsequently separated by double ligatures with cotton string. Each segment was opened, and the contents were stored in an individual container, with a 10% aliquot of this content taken for preservation in 5% formalin [20]. Parasite counts obtained from the 10% aliquot were multiplied by 10 to estimate the total number of parasites in each segment, in accordance with WAAVP guidelines, ensuring accurate assessment of infection intensity.

The counting and identification of adult forms of parasites recovered from the gastrointestinal tract of necropsied animals in the prospective study were carried out using a stereomicroscope. Morphological identification of *H. contortus* was confirmed based on key diagnostic features, including body length and shape, the presence of the characteristic “barber pole” appearance of females, the structure of the buccal capsule, esophageal length, and spicule morphology in males, following the taxonomic criteria described by Ueno and Gonçalves [20]. Infection intensity was classified according to the number of parasites: mild (<500), moderate (500–1500), and severe (>1500).

Descriptive statistical analysis was used to calculate the frequencies of the results obtained. The dependent variable, positivity, was defined as the presence of *H. contortus* infection confirmed through necropsy and morphological identification. Independent variables included epidemiological factors (sex, age, breed, origin, herd size, and breeding system), clinical information (body condition score, presence of anorexia, apathy, emaciation, diarrhea, decubitus, dyspnea, paresis, and fur aspect), and pathological findings (abomasal lesions and other relevant organ alterations).

Univariate associations between each independent variable and positivity were assessed using chi-square or Fisher’s exact tests, with a significance level of 5%. Statistical assumptions, including expected cell counts and independence of observations, were verified prior to analysis. Although multivariate analysis (e.g., logistic regression) was considered, the sample size and distribution of cases limited its feasibility. Therefore, univariate analyses were used as the most appropriate approach to identify potential associations in this epidemiological dataset. Analyses were performed using GraphPad Prism 8.0.1 software.

3. Results

Retrospective study: During the retrospective study haemonchosis was observed in 11.8% (47/398) goats and 14.4% (44/309) sheep.

Prospective study: During the prospective study, haemonchosis was observed in 25% (3/12) goats and 38.5% (5/13) sheep. Although the sample size was limited, these cases were included to complement the retrospective findings with current observations under similar regional conditions. Data on parasitic load and infection severity are presented in Table 1.

Combined analysis: For spatial and descriptive purposes, data from both retrospective and prospective studies were combined to represent all confirmed cases of haemonchosis (totaling 50 goats and 49 sheep). Figures 1 and 2 illustrate the geographical origin of these animals, encompassing both study periods. The affected goats originated mainly from municipalities in Paraíba (94%; 47/50), Pernambuco (4%; 2/50), and Rio Grande do Norte (2%; 1/50) (Figure 1), while most affected sheep came from Paraíba (88%; 43/49), followed by Ceará (6%; 3/49), Pernambuco (4%; 2/49), and Rio Grande do Norte (2%; 1/49) (Figure 2).

Table 1. Parasitic load and severity of *Haemonchus contortus* infection in small ruminants necropsied in a semiarid region of Northeast Brazil, from January to December 2022.

	Quantity of Parasites			Infection Classification *
	Males	Females	Total	
Sheep				
1	7450	10,900	18,350	severe
2	1430	2550	3980	severe
3	60	130	190	mild
4	160	370	530	moderate
5	130	210	340	mild
Goats				
1	2560	1665	4225	severe
2	960	580	1540	severe
3	210	170	380	mild

* According to Ueno and Gonçalves [20].

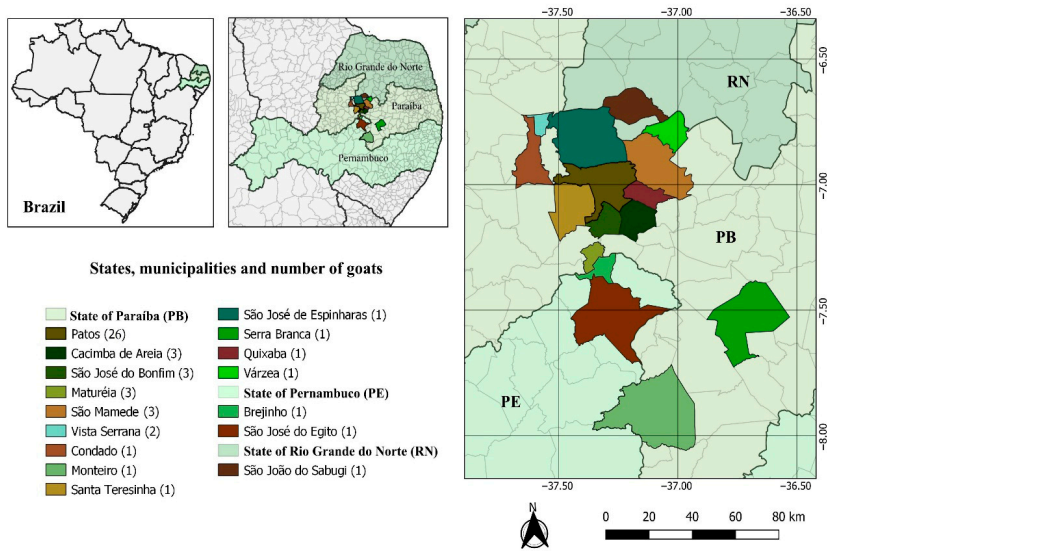


Figure 1. Geographic distribution and number of goats necropsied with *Haemonchus contortus* infection in a semiarid region of Northeast Brazil, from January 2012 to December 2022.

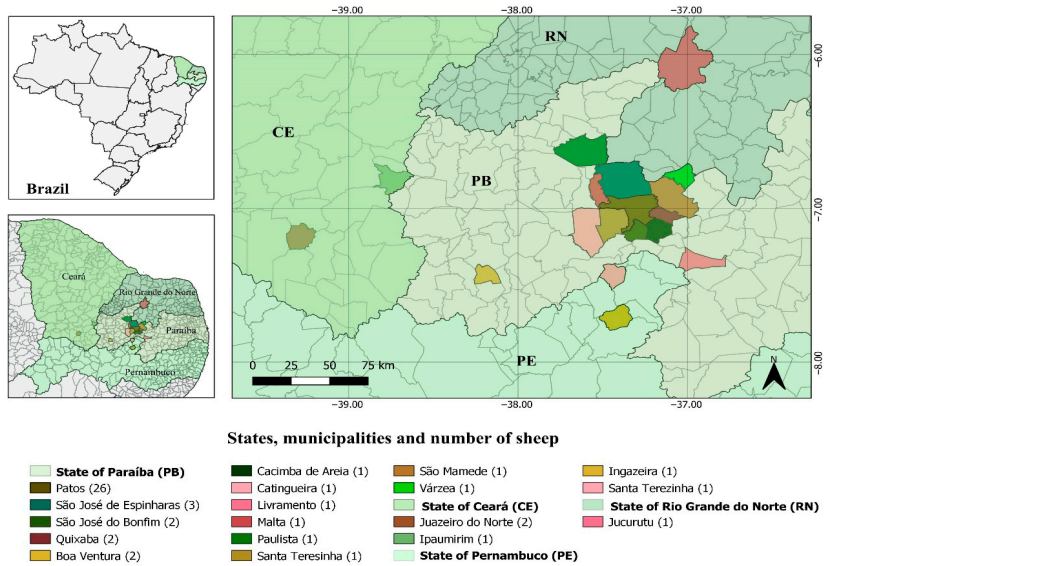


Figure 2. Geographic distribution and number of sheep necropsied with *Haemonchus contortus* infection in a semiarid region of Northeast Brazil, from January 2012 to December 2022.

Epidemiological data (Table 2) indicated that female goats were most affected (45/50, 90%; $p \leq 0.05$), particularly in the 13–35 months age range (25/50, 50%; $p \leq 0.05$), and among crossbred animals (38/50, 76%; $p \leq 0.05$). Both goats and sheep raised under semi-intensive systems were significantly more affected (41/50, 82%; and 36/49, 76.5%; $p \leq 0.05$).

Table 2. Epidemiological aspects of haemonchosis in small ruminants necropsied at the Animal Pathology Laboratory, Federal University of Campina Grande, from 2012 to 2022.

Variables		Goats		Sheep	
		Total	%	Total	%
Gender					
	Male	5	10	22	44.9
	Female	45 *	90	27	55.1
Age (months)					
	≤ 12	8	16	12	24.5
	13–35	25 *	50	21	42.8
	≥ 36	8	16	12	24.5
	Not informed	9	18	4	8.2
Breed					
	Crossbred	38 *	76	24	49
	Boer	9	18	-	-
	Saanen	2	4	-	-
	Alpine Brown	1	2	-	-
	Dorper	-	-	15	30.6
	Santa Inês	-	-	8	16.3
	Morada Nova	-	-	2	4.1
Deworming					
	≤ 3 months	17	34	16	32.7
	> 3 months	14	28	21	42.8
	No	19	38	12	24.5
Raising System					
	Intensive	4	8	4	8.2
	Semi-intensive	41 *	82	36 *	73.5
	Extensive	5	10	9	18.3
Herd					
	≤ 10 animals	17	34	15	30.6
	11–99 animals	11	22	26	53.1
	≥ 100 animals	22	44	8	16.3

* Statistically significant difference according to chi-square or Fisher's exact tests ($p \leq 0.05$).

Haemonchosis occurred mainly from February to December, with peaks in May (30%; 15/50) for goats and September (26.5%; 13/49) for sheep. Moderate infections were the most frequent, representing 44% (22/50) in goats and 49% (24/49) in sheep, followed by severe (40%; 20/50 and 36.7%; 18/49) and mild infections (16%; 8/50 and 14.3%; 7/49). The main clinical and pathological aspects are summarized in Table 3. The proportion of goats (32/50, 64%) and sheep (30/49, 61.2%) with a normal body condition score was significantly different ($p \leq 0.05$). At necropsy, significant findings ($p \leq 0.05$) for both species included the presence of *H. contortus* in the abomasum (100%) and mucosal and carcass pallor (56% and 71.4%, respectively), as illustrated in Figure 3.

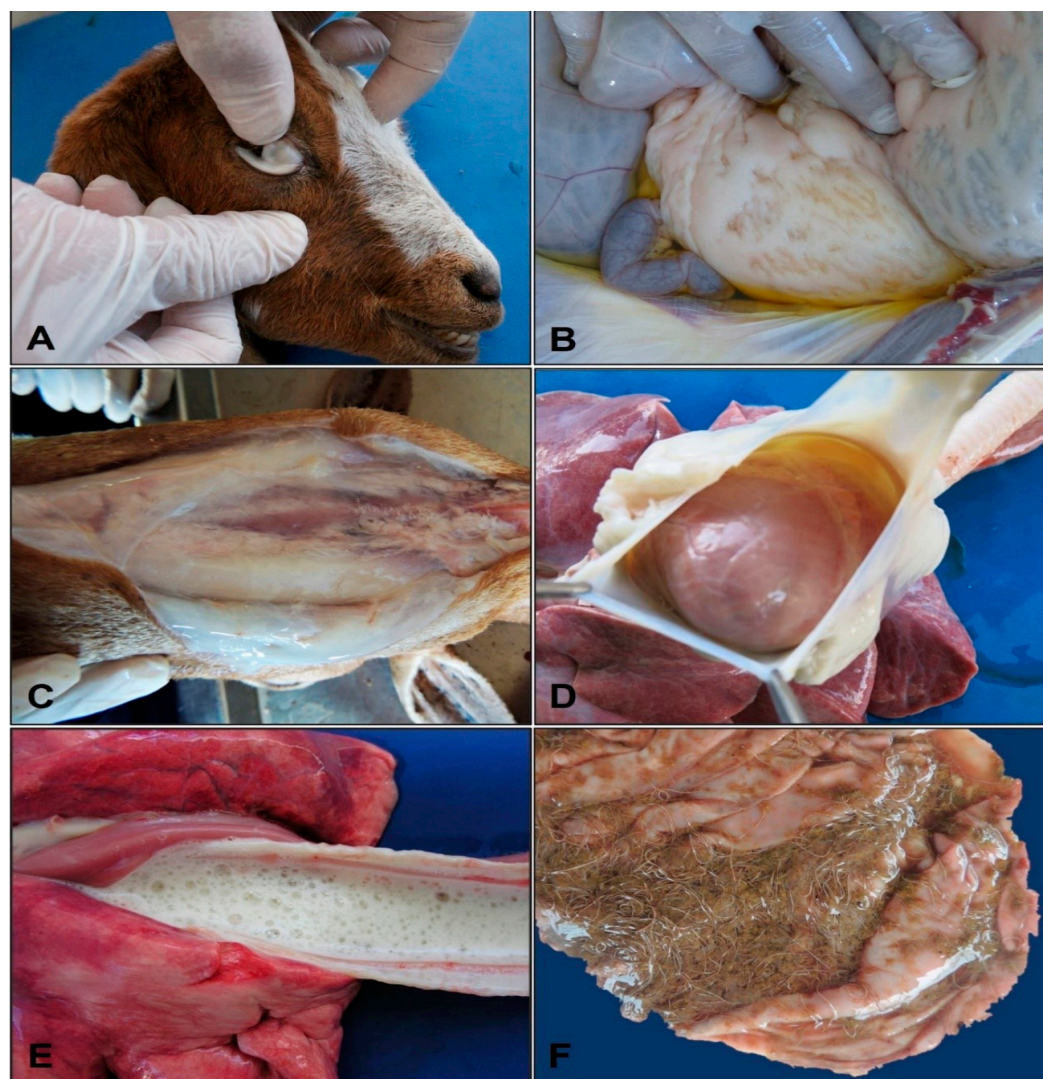


Figure 3. Haemonchosis in small ruminants. (A) Goat: marked paleness of the ocular mucosa. (B) Goat: yellowish transudate in the abdominal cavity (ascites). (C) Goat: subcutaneous edema in the submandibular region. (D) Sheep: yellowish transudate in the pericardial sac (hydropericardium). (E) Goat: foamy content in the trachea (pulmonary edema). (F) Sheep: *Haemonchus contortus* parasites on the abomasal mucosa.

Table 3. Clinical and pathological aspects of haemonchosis in small ruminants necropsied at the Animal Pathology Laboratory, Federal University of Campina Grande, from 2012 to 2022.

Findings	Goats		Sheep	
	Total	%	Total	%
Clinical Signs				
Body Condition Score				
Normal	32 *	64	30 *	61.2
Thin	14	28	15	30.6
Emaciated	4	8	4	8.2
Anorexia	18	36	12	24.5
Apathy	14	28	15	30.6
Emaciation	8	16	8	16.3
Diarrhea	8	16	4	8.2
Decubitus	6	12	6	12.2
Dyspnea	5	10	4	8.2

Table 3. Cont.

Findings	Goats		Sheep	
	Total	%	Total	%
Paresis	4	8	4	8.2
Raised Fur	2	4	4	8.2
Pathological Signs				
<i>H. contortus</i> on the abomasum	50 *	100	49 *	100
Pale mucous and carcass	28 *	56	35 *	71.4
Pulmonary edema	16	32	13	26.5
Hydropericardium	14	28	14	28.6
Subcutaneous edema	9	18	12	24.5
Hydrothorax	8	16	10	20.4
Ascites	8	16	11	22.5
Atrophy of cardiac fat	6	12	4	8.2
Mesenteric edema	5	10	2	4.1
Abomasal ulcers	5	10	2	4.1
Edema of the abomasal wall	1	2	3	6.1
Concurrent parasitic infections				
<i>Oesophagostomum columbianum</i>	10	20	8	16.3
<i>Cysticercus tenuicollis</i>	7	14	4	8.2
<i>Moniezia expansa</i>	4	8	2	4.1
<i>Trichostrongylus axei</i>	3	6	2	4.1
<i>Trichuris ovis</i>	1	2	2	4.1

* Statistically significant difference according to chi-square or Fisher's exact tests ($p \leq 0.05$).

4. Discussion

Haemonchosis remains one of the most significant parasitic diseases affecting small ruminants worldwide, particularly in tropical and subtropical regions. The present study provides an integrated analysis of the epidemiological, clinical, and pathological characteristics of *Haemonchus contortus* infection in sheep and goats reared under semiarid conditions in Northeastern Brazil, combining retrospective and prospective data obtained over a ten-year period. The diagnosis of haemonchosis was established based on epidemiological, clinical, and pathological findings. This condition represents a significant disease for small ruminants in the semi-arid of the Northeast region of Brazil and is a recognized limiting factor for animal production. It is an endemic disease, with prevalence rates in small ruminants determined through coproparasitological exams measuring eggs per gram of feces (EPG) reaching approximately 80% [18,21,22]. This study considered only the direct visualization of parasites in the abomasum and only in animals undergoing necropsy at APL-UFCG, with infection observed in 12% of the goats and 15% of the sheep. These data are similar to those observed in other regions of the country and the world, where infections by *H. contortus* account for 14.5% to 22.2% of the total diagnoses of necropsies [23–25].

The low frequency of observing *H. contortus* in this study may be primarily related to the deworming protocol carried out during clinical hospitalization in animals with haemonchosis that reduces the parasitic load [26]. Also, the interval between the animal's death and necropsy can lead to the displacement of parasites to subsequent organs [27]. Additionally, the small size of the parasites, which in mild infections can go unnoticed, and the diagnosis of haemonchosis can be underreported. In circumstances where the cause of death is not related to the gastrointestinal tract, there may be neglect in inspecting the abomasum [28], as confirmed by the results of the prospective study, when were performed more detailed necropsies on the gastrointestinal tract, increasing the diagnosis of haemonchosis in goats and sheep.

Females may be more susceptible to infection during specific physiological periods, such as the peripartum and lactation phases, due to immunosuppression and negative energy balance [23,29]. Supporting literature on female susceptibility associated with periparturient immunosuppression was also added [30,31]. The lower frequency of observed infections in males in our study likely reflects the shorter lifespan of males, as they are typically slaughtered at a younger age [28], rather than a true lower susceptibility.

In this study, the highest prevalence of haemonchosis occurred in adult animals, similar to what has been observed in other studies [26,29,32]. This may also be related to the profile of animals referred for treatment at the veterinary hospital. However, it is known that young animals are more susceptible when compared to adults, who exhibit a better immune response due to frequent exposure to natural infections in pastures [33]. Additionally, grazing habits, management practices, the breeding system, and habitat are factors that can influence the prevalence of infection among different categories [25].

It is likely that the higher occurrence of haemonchosis in crossbred animals is related to this being the predominant profile of animals raised in the study region [23,24], which generally do not have a defined breed standard and are not subjected to assisted crossbreeding. Although it is believed that some breeds are more resistant to infection, such as Santa Inês and Morada Nova sheep [33], while Dorper sheep and Boer goats appear to be more susceptible [34].

The significant frequency of the disease in animals raised under semi-intensive management (81.6% in goats and 72.9% in sheep) may be attributed to housing conditions that predispose the animals to increased contact with their excreta, a situation that favors the transmission of infection among animals within the same herd [21]. Indeed, in the present study, concomitant infections by other parasitic agents such as *Cysticercus tenuicollis*, *Moniezia expansa*, *Oesophagostomum columbianum*, *Trichostrongylus axei*, and *Trichuris ovis* were observed.

The clinical signs and necropsy findings reflect the marked debilitating effect of parasites on the host, which, through their blood-feeding activity, can trigger severe anemia. It is estimated that each worm can suck up to 0.05 mL of blood daily, which, coupled with the high parasitic load, can lead to the death of the animal [35]. Also, the physical and chemical damage to the abomasal mucosa induces changes in the local pH, circulatory disorders, and inflammatory processes, resulting in anorexia, poor absorption, weight loss, and tend to be progressive, worsening the clinical condition [36].

Despite the high parasitic load observed in some animals, a considerable number did not exhibit marked anemia or cachexia. This apparent inconsistency is consistent with the concept of resilience, in which certain animals are able to maintain adequate body condition despite high parasite burdens. Such adaptive responses have been reported in tropical and semiarid regions, where repeated exposure to infection favors the development of partial immunity and clinical tolerance [5,33,37].

In this study, some of the affected animals had been recently dewormed. Even though, parasitism by *H. contortus* was observed. Anthelmintic resistance represents the main obstacle to disease control in the semi-arid regions [15,38,39]. An alternative to overcome resistance is the use of the FAMACHA® method, which involves deworming only symptomatic animals, significantly reducing the use of anthelmintics [40]. Alternative control methods such as rotational grazing, reduction in pasture stocking rates, and alternating grazing with cattle may be effective in reducing the disease [7,41–43].

Because this study relied on retrospective and prospective necropsy records, quantitative correlations between parasite burden and macroscopic lesions were limited. Nevertheless, the mild–moderate–severe classification provides a practical diagnostic framework. Statistical analysis used univariate tests (chi-square and Fisher's exact), appropriate for

the categorical variables and sample size; multivariate approaches were considered but limited by the low number of positive cases. The geographic maps included were designed solely to depict the spatial distribution of confirmed cases. Because the dataset was based on necropsy submissions rather than systematic field sampling, spatial or environmental correlations (e.g., with rainfall or temperature) could not be reliably assessed. These limitations are now explicitly acknowledged to avoid misinterpretation of the spatial data.

5. Conclusions

Haemonchosis is an important parasitic disease affecting goats and sheep in the semi-arid region of Northeast Brazil, causing animal deaths and reductions in productivity. The higher prevalence observed in females and adults likely reflects herd demographics rather than inherent susceptibility, while the presence of animals with normal body condition despite high parasite burdens highlights the role of resilience in herd health. Thorough necropsies provide a more accurate estimate of infection prevalence, although limitations such as the small prospective sample and potential underestimation in retrospective records should be considered. These findings underscore the importance of targeted parasite control and the implementation of practical strategies, including FAMACHA® monitoring, selective deworming, and improved pasture management, to mitigate the impact of haemonchosis and associated economic losses.

Author Contributions: All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by A.M.O., E.P.F.S., A.A.R.M.A., V.H.A.S.F., T.F.F. and V.L.R.V. The first draft of the manuscript was written by A.M.O., T.F.F., A.F.M.D. and V.L.R.V.; and all authors commented on previous versions of the manuscript. All authors have read and agreed to the published version of the manuscript.

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Informed Consent Statement: Not applicable.

Data Availability Statement: The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest: The authors declare that they did not have any conflict of interest relevant to the content of this article. Given his role as Associate Editor, Vinícius Vilela had no involvement in the peer review of this article and has no access to information regarding its peer review.

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