Revista Ensaios e Ciência
ISSN 1415-6938 e ISSN 2178-695X

DOI: https://doi.org/10.17921/1415-6938.2026v30n2p307-323

Gastrointestinal Parasites and Associated Risk Factors in Smallholder Pig Farms in the State of Maranhão, Brazil

parasitos gastrointestinais e Fatores de Risco Associados em Criações Familiares de Suínos no Estado do Maranhão, Brasil

Received: April 2026
Accepted: July 2026

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Abstract

Swine farming is an important socioeconomic activity in Brazil. However, parasitic infections can affect animal productivity and pose zoonotic risks to producers. This study assessed the prevalence, intensity, and associated risk factors of gastrointestinal parasitic infections in swine from Southern Maranhão, Northeast Brazil. Fecal samples (n=55) were processed using the centrifugal flotation technique adapted to estimate the parasite intensity. Concurrently, a semi-structured questionnaire was used to characterize the farming practices and sociodemographic profiles of the producers. We demonstrated that most producers had a low educational level (43%) and income (71%), and most animals consumed untreated water (86%) provided in troughs (71%) and a mixed diet (organic domestic residues and swine feed) (43%). The prevalence of low-intensity parasite infection was 38% (n=21). The identified parasites included Coccidia (n=17; 31%), Strongylida (n=8; 15%), *Entamoeba* spp. (n=4; 7%), *Ascaris* spp. (n=2; 4%), and *Trichuris* spp. (n=1; 2%). Co-infections among these parasite groups were identified in seven animals (13%). The prevalence was significantly higher in females (p=0.03) and in animals consuming untreated water (86%; p=0.05). These findings indicate that swine raised on small farms in Southern Maranhão, Brazil harbor a diverse assemblage of gastrointestinal helminths and protozoa, highlighting the relevance of sanitary management practices in small-scale pig farming systems.

Keywords: Helminths. One Health. Protozoa. Sanitary Management.

Resumo

A suinocultura é uma atividade socioeconômica importante no Brasil. No entanto, infecções parasitárias podem afetar a produtividade animal e representar riscos zoonóticos aos produtores. Assim, este estudo avaliou a prevalência, a intensidade e os fatores de risco associados a infecções parasitárias gastrointestinais em pequenas granjas de suínos do Sul do Maranhão, Nordeste do Brasil. Amostras fecais (n=55) foram processadas utilizando a técnica de centrífugo-flutuação adaptada para estimar a intensidade parasitária. Simultaneamente, um questionário semiestruturado foi utilizado para caracterizar as práticas de manejo e o perfil sociodemográfico dos produtores. Demonstramos que a maioria dos produtores possuía baixo nível de escolaridade (43%) e renda (71%), e a maioria dos animais consumia água não tratada (86%) fornecida em cochos (71%) e dieta mista (resíduos domésticos orgânicos e ração suína) (43%). A prevalência foi de 38% (n=21) e todos os animais infectados apresentaram baixa carga parasitária. Os parasitos identificados foram, Coccídeos (n=17; 31%), Strongylida (n=8; 15%), *Entamoeba* spp. (n=4; 7%), *Ascaris* spp. (n=2; 4%) e *Trichuris* spp. (n=1; 2%). Coinfecções entre esses grupos de parasitos foram identificadas em sete animais (13%). A prevalência foi significativamente maior em fêmeas (p=0,03) e em animais que consumiam água não tratada (86%; p=0,05). Esses achados indicam que suínos criados em pequenas propriedades no Sul do Maranhão, Brasil, abrigam um conjunto diversificado de helmintos e protozoários gastrointestinais, destacando a relevância de práticas de manejo sanitário em sistemas de suinocultura em pequenas propriedades.

Palavras-chave: Helmintos. Manejo sanitário. Protozoários. Saúde Única.

1 Introduction

Pig farming is a prominent agricultural activity in Brazil. Currently, the country ranks

fourth in global pork production, with an output of 5.155 million tons in 2023 (ABPA, 2023). Despite advancements in the Brazilian swine industry, a significant portion of production is concentrated in smallholdings, where animals are typically raised as a primary or secondary source of income and/or for subsistence (Class *et al*., 2020).

The "caipira" (free-range) or extensive rearing system is the primary method adopted by small-scale producers and is prevalent in most family farming operations (Silva; Silva, 2021). However, subsistence rearing often follows rustic models characterized by limited technical assistance, as well as precarious management and sanitary conditions (Rocha *et al*., 2016). Sanitary management is essential for maintaining high productivity in swine farming because it promotes animal health and ensures food safety for consumers (Machado *et al*., 2022).

A key factor that needs to be evaluated in swine sanitary management is the presence of gastrointestinal parasites. Uncontrolled parasite populations can lead to retarded growth, poor feed conversion, increased costs for treatment and prophylaxis, higher susceptibility to other diseases, and organ condemnation at slaughter (Kagira *et al*., 2012; Kipper *et al*., 2011; Kouam; Ngueguim, 2022; Lai *et al*., 2011; Martínez-Pérez *et al*., 2017; Oba *et al*., 2023). The gastrointestinal parasites in swine primarily include helminths and protozoans. The most frequent parasites reported in the literature include *Cystoisospora* suis, *Balantidium coli*, *Entamoeba* spp., *Eimeria* spp., *Giardia* spp., *Ascaris suum*, *Trichuris suis*, *Strongyloides* spp., and *Oesophagostomum* spp. (Adhikari *et al*., 2021; Barbosa *et al*., 2015; Bregonde *et al*., 2022; Symeonidou *et al*., 2020; Widisuputri *et al*., 2020). Some of these parasites (e.g., *A. suum*, *B. coli*, and *Entamoeba* spp.) possess zoonotic potential, being capable of infecting humans (Monteiro *et al*., 2019; Li *et al*., 2022; Solaymani-Mohammadi; Petri, 2006). Consequently, professionals in the swine industry may be directly affected by these para-sites (Symeonidou *et al*., 2020).

Variations in the prevalence and intensity of endoparasite infections in pigs depend on factors related to climatic conditions, management systems, and farm infrastructure (Mattos *et al*., 2020). Therefore, epidemiological studies on swine parasites should incorporate analyses of rearing conditions to better understand parasite–host dynamics at the farm level. Despite its relevance to the swine industry, few studies have been conducted in Maranhão. To date, only one study (Silva *et al*., 2015) has evaluated the prevalence of gastrointestinal parasites in pigs raised in Maranhão, specifically in the northern region (Baixada Ocidental Maranhense), where environmental conditions, rearing types, and management practices differ from those in the southern region of the state.

Therefore, this study aimed to expand the knowledge of the main gastrointestinalparasites

affecting swine raised in Brazil by conducting a parasitological survey on properties in the municipality of São Raimundo das Mangabeiras in southern Maranhão State, Northeast Brazil. Additionally, it aims to promote the transfer of information regarding these infections and their control to producers.

2 Material and Methods

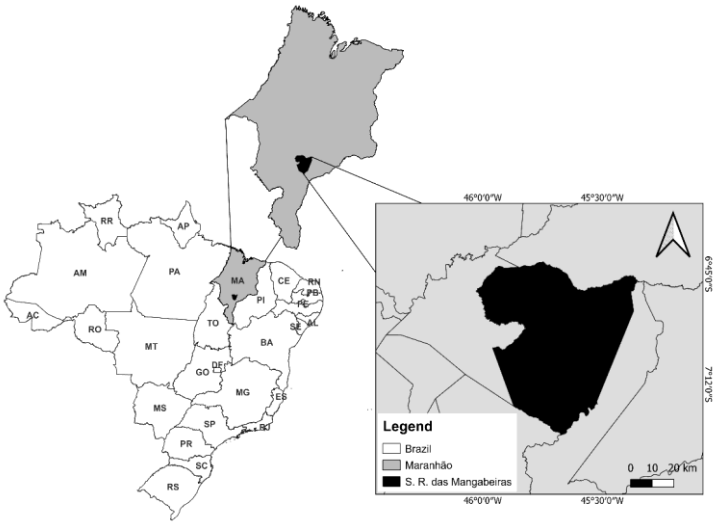
2.1 Ethical considerations

This research was approved by the Ethics Committee on Animal Use (CEUA/IFMA No. 51/2023) and the Ethics Committee for Research Involving Human Beings and all project details have been registered on the Brazilian Platform (CAAE: 74022923.8.0000.5087 and approval number: 6.619.237), authorizing the collection of animal samples and data from producers.

2.2 Study area

This study was conducted from November 2023 to August 2024 on small swine farms with family production systems, located in the municipality of São Raimundo das Mangabeiras, Southern Maranhão Mesoregion (Figure 1). The municipality stands at an altitude of 225 m above sea level, with low thermal variation and temperatures ranging between 20.8°C and 32.1°C throughout the year. The regional climate is classified as dry subhumid tropical (Aw') and is characterized by two distinct periods: the rainy season from November to April and the dry season from May to October (Correia Filho *et al*., 2011). The study area is located in a region dominated by the Cerrado biome.

Figure 1 – Geographical location of the study area in Southern Maranhão, Northeast Brazil



Source: resource data.

Due to limited official data regarding the number of small-scale swine farms in São Raimundo das Mangabeiras, properties were selected via snowball sampling and convenience, based on accessibility and voluntary participation of producers through signed informed consent

2.3 Animal characteristics and rearing conditions

Animal characteristics and rearing conditions were assessed using a semi-structured questionnaire adapted from Alencar *et al*. (2011) and Pinilla *et al*. (2020) and administered at the time of sample collection. All questionnaire items related to animal management were read aloud to the owners to facilitate their understanding. The questionnaire was used to collect herd data, such as sex, age group, rearing system, cleaning protocols for the facilities, number of animals, diet type, water source, access to veterinary assistance, anthelmintic strategies, quarantine practices, and prior fecal examinations. Additionally, the producers were surveyed for their gender, educational level, income, and knowledge of parasitic diseases in swine.

2.4 Sample collection and parasitological analysis

Approximately 10 g of feces were collected directly from the rectum (to avoid soil contamination) using a rectal palpation glove lubricated with glycerin or a swab for piglets (Thienpont; Rochette; Vanparijs, 2003). Subsequently, fecal samples were individually placed in lidded containers identified by animal and property, stored in a thermal box, and transported to the Laboratory of Microbiology and Biotechnology (LAMBIO) at the Federal Institute of Education, Science, and Technology of Maranhão (IFMA) in São Raimundo das Mangabeiras for parasitological analyses.

Fecal samples were processed to evaluate the presence of helminth eggs and gastrointestinal protozoan cysts, oocysts, and trophozoites using centrifugal flotation techniques (Sheather, 1923), with modifications to quantify the infection intensity. Parasitic evolutionary forms were identified on the basis of their morphological characteristics (Honer, 1967; Stewart; Stromberg; Lawhorn, 1994; Thienpont; Rochette; Vanparijs, 2003; Lukyanova; Yagenich; Pasechnik, 2020).

Briefly, 2 g of feces was weighed on a digital scale and homogenized in a beaker containing 40 mL of a hypersaturated solution of 4% sodium chloride (NaCl) and 5% sucrose with a specific gravity of 1.280 (Roesel *et al*., 2017). The solution was filtered through a gauze into a new beaker, transferred to a 50 mL Falcon tube, and centrifuged at 300 ×g for 5 min

(Sheather, 1923). To quantify the infection intensity, a 1.5 mL aliquot of the supernatant was collected and placed in microtubes containing 0.5 mL of 10% formalin. After homogenization, two 100 µL aliquots from each sample were stained with Lugol's iodine on glass slides and examined under an optical microscope. The mean number of eggs, cysts, oocysts, and/or trophozoites per fecal aliquot (100 µL) was extrapolated to the total volume of 2 mL (representing the parasite content in the initial 2 g of feces). These values were then divided by two to represent the number of each parasitic evolutionary form per gram of feces.

2.5 Technical support for producers

On the basis of the questionnaire data and parasitological results, an educational booklet was developed using the Canva® software. The material utilized accessible language and visual elements to facilitate the producers' understanding. The objective of this study was to enhance their knowledge of gastrointestinal parasites in swine, their impact on production, and preventive management strategies.

2.6 Statistical analysis

Data obtained from the questionnaires and parasitological analyses are expressed as absolute numbers and percentages (%). The prevalence calculations were performed separately for each family, genus, and parasitic species identified. The Chi-square test was used to compare the frequencies of specific parasite groups according to animal characteristics, rearing conditions, and socioeconomic data. Statistical significance was set at $p \leq 0.05$. Statistical analyses were performed using the STATA software, version 11.1 (StataCorp, College Station, TX, USA).

3 Results and Discussion

Seven properties were evaluated on the basis of the established selection criteria. According to the sociodemographic profile of the owners (Table 1), most producers were male (n=6; 86%), less than half had completed primary education (n=3; 43%), and most reported an income of less than one minimum wage (n=5; 71%). Furthermore, most interviewed producers (n=5; 71%) were already aware of swine parasites, and they routinely performed anthelmintic treatments. These socioeconomic conditions may contribute to a lack of knowledge regarding best management practices, which directly increases the occurrence of parasitic infections.

Table 1 – Demographic and socioeconomic profile of small swine producers in São Raimundo das Mangabeiras, Maranhão, Brazil

Producers Data (n=7)		**N (%)**
Gender	Male	6 (86)
	Female	1 (14)
Education level	Incomplete primary education	3 (43)
	Complete primary education	2 (29)
	Incomplete secondary education	1 (14)
	Complete secondary education	0 (0)
	Higher education	1 (14)
Income	≤ Minimum wage	5 (71)
	> Minimum wage	2 (29)
Awareness of swine parasites	Yes	5 (71)
	No	2 (29)

Source: research data.

The properties housed a total of 61 pigs. The numbers of male and female pigs showed a similar distribution, and most were younger than 4 months (n=32; 52%) (Table 2).

Table 2 – Characteristics of the evaluated swine and management profile in small swine farms in São Raimundo das Mangabeiras, Maranhão, Brazil

Swine (n=61)		**N (%)**
Sex	Male	30 (49)
	Female	31 (51)
Age	<4 months	32 (52)
	4–8 months	15 (25)
	>8 months	14 (23)
Management profile (n=7)		N (%)
Free-range rearing	Yes	0 (0)
	No	7 (100)
Herd size	<10	3 (43)
	>10	4 (57)
Type of feed	Swine feed	2 (28,5)
	Organic domestic residues	2 (28,5)
	Mixed diet	3 (43)
Treated water	Yes	1 (14)
	No	6 (86)
Drinker type	Nipple drinker	2 (29)
	Trough	5 (71)
Facility cleaning	Waste removal (dry)	1 (14)
	Water jet	4 (57)
	No removal	2 (29)
Waste disposal	Open air	6 (86)
	Septic tank	1 (14)
Veterinary assistance	Yes	1 (14)
	No	6 (86)
Quarantine for new animals	Yes	3 (43)
	No	4 (57)
Anthelmintic use	Yes	7 (100)
	No	0 (0)
Periodic fecal exams	Yes	0 (0)
	No	7 (100)

Source: research data.

Animals in all evaluated properties were raised under confinement (n=7; 100%), with herd sizes generally exceeding 10 (n=4; 57%) (Figure 2.E and F). On most properties, the animals were fed a mixed diet (swine feed and organic domestic residues) (n=3; 43%) (Figure 2.D), and the water provided was untreated (n=6; 86%) and supplied in troughs (n=5; 71%) (Figure 2.A, B, and C). Furthermore, most producers performed cleaning with water jets (n=4; 57%), and most swine waste was disposed of in the open air (n=6; 86%). Finally, the vast majority of owners lacked veterinary assistance (n=6; 86%), none performed periodic fecal examinations of the animals (n=7; 100%), and most did not adopt a quarantine system for new animals (n=4; 57%). However, all producers administered anthelminthics on their own initiative (Table 2).

Figure 2 – Rustic swine-farming conditions in São Raimundo das Mangabeiras, Southern Maranhão, Brazil. A. Feeding area. B. Watering area and animal shelter. C. Mud puddle at the rearing site. D. Pig feeding on domestic organic residues. E. Type of animal confinement. F. Pig wallowing in mud

Souce: the authors.

Of the 61 pigs present on the properties, we could not collect samples from six animals because of hostile behavior or the absence of feces in the rectal ampulla at the time of collection; therefore, 55 fecal samples were analyzed. Among these samples, 38% (n=21) showed

gastrointestinal parasite infections (protozoa and/or helminths). All infected animals presented with unsporulated oocysts or cysts, and approximately 43% (n=9) were infected with helminths (Table 3).

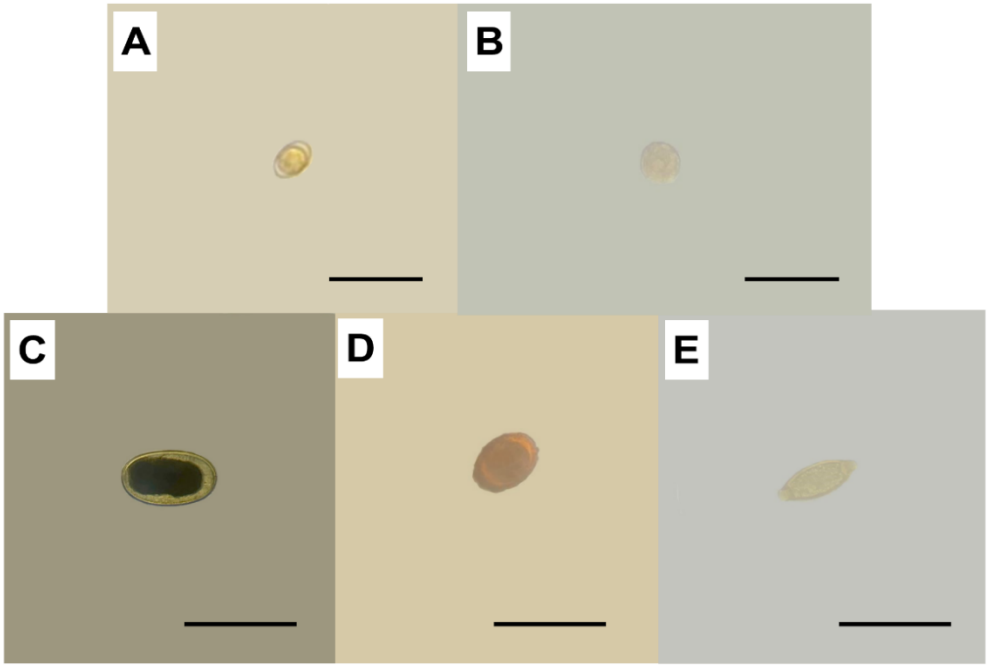
Table 3 – Prevalence and intensity of gastrointestinal parasite infection in swine raised in small farms in São Raimundo das Mangabeiras, Maranhão, Brazil

Swine (n=55)	**N (%)**
Uninfected	34 (62)
Infected	21 (38)
Protozoa	**N (%)**
Coccidia	17 (31)
Entamoeba sp.	4 (7)
Helminths	**N (%)**
Strongylida	8 (15)
Ascaris spp	2 (4)
Trichuris spp	1 (2)
Parasite intentisty	**Mean and standard error**
Coccidia	91.7±66.2 oocysts
Entamoeba sp.	13.3±8.3 cysts
Strongylida	57.5±28.7 eggs
Ascaris spp	12.5±7.5 eggs
Trichuris spp	20 eggs

Source: research data.

The protozoa identified were Coccidia (n=17; 31%) (Figure 3.A) and *Entamoeba* spp. (n=4; 7%) (Figure 3.B). The helminths detected belonged to the order Strongylida (n=8; 15%) (Figure 3.C), *Ascaris* spp. (n=2; 4%) (Figure 3.D), and *Trichuris* spp. (n=1; 2%) (Figure 3.E). Co-infections among these parasite groups were identified in seven animals (13%), with dual infections of Coccidia and Strongylida being the most frequent (Table 3). Among the protozoa, Coccidia showed the highest parasitic intensity, whereas the Strongylida showed the highest values among the helminths (Table 3).

Figure 3 – Evolutionary stages of gastrointestinal parasites found in swine raised in São Raimundo das Mangabeiras, Southern Maranhão, Brazil. A. Unsporulated coccidian oocyst. B. *Entamoeba* spp. cyst. C. Helminth egg of the order Strngylida. D. *Ascaris* spp. egg. E. *Trichuris* spp. egg. Scale bars=50 µm.



Source: the authors

The parasitological profile of the pigs evaluated in the present study reveals the simultaneous circulation of protozoan and helminth parasites in small-scale swine production systems. These data align with findings from other studies in Northeastern Brazil, which reported infection rates ranging from 44% to 48% (Rocha *et al*., 2021; Jesus *et al*., 2024). The parasite diversity found in our study is consistent data from Brazil, Indonesia, Greece, and Nepal (Adhikari *et al*., 2021; Barbosa *et al*., 2015; Bregonde *et al*., 2022; Symeonidou *et al*., 2020; Widisuputri *et al*., 2020).

A previous study (Silva *et al*., 2015) in Maranhão found a diverse range of parasites, including specimens from the superfamily Strongyloidea, *Strongyloides* spp., *Trichuris* suis, *Ascaris suum*, *Metastrongylus* spp., coccidians, *Balantidium coli*, *Entamoeba* coli, and *Macracanthorhynchus hirudinaceus*. These data suggest that these parasites have adapted to various climatic regimes and management conditions.

Moreover, it is crucial to highlight the zoonotic potential of some of these agents, such as *Ascaris*, *Trichuris*, and *Entamoeba* (Li *et al*., 2022; Monteiro *et al*., 2019; Solaymani-Mohammadi; Petri, 2006). In Southeast Brazil, evidence of cross-infections and hybridization

of *Ascaris* between pigs and humans has been reported in Guarani villages (Boeira *et al*., 2025). These under-scores the necessity for swine parasite studies to adopt a One Health perspective to better comprehend the infection dynamics and propose more effective control measures.

We also observed a co-infection rate of 15% among the analyzed samples, with dual infections being the most prevalent. This finding is consistent with those of Pinilla *et al*. (2020) and Carreiro *et al*. (2021), who reported that most animals were co-infected with two or more parasite genera.

Co-infection may be explained by the similarity in life cycles of gastrointestinal parasites, which are primarily transmitted via contaminated water or feed. In addition, the infections evaluated in our study showed oocyst and egg counts below 500 per gram of feces, and they were thus classified as low-intensity infections (Euzeby, 1981; Taylor; Coop; Wall, 2017).

Although a low parasite burden may not result in overt clinical signs, the animals may exhibit reduced productivity (Kouam; Ngueguim, 2022). Therefore, we recommend appropriate pharmacological treatment combined with prophylactic practices to minimize production loss, even in low-intensity infections.

Regarding management characteristics, swine production in São Raimundo das Mangabeiras is predominantly extensive and focused on family subsistence, and it presents gaps in sanitary management. This small-scale farming model represents a critical economic driver in developing countries, including Brazil (Class *et al*., 2020; Araújo *et al*., 2020). Due to the limited investment inherent in small-scale farming, the high prevalence of gastrointestinal parasites observed in this study underscores the urgent need for government intervention.

According to Class *et al*. (2025), establishing cooperatives could help organize and formalize these production systems, enabling official recognition and directed investments in animal health to control parasitic agents.

To calculate the risk factors associated with parasitic infections in the evaluated swine, the overall prevalence (n=21; 38%) was compared across sex, age, and management practices. Parasitic infections were significantly more prevalent in females (71.5%; p=0.03) than in males and in animals that consumed untreated water (86%; p=0.05) than in those that consumed treated water (Table 4).

Table 4 – Risk factors associated with the presence of gastrointestinal parasites in small swine farms in São Raimundo das Mangabeiras, Maranhão, Brazil

Swine (n=55)	Uninfected (n=34) N (%)	Infected (n=21) N (%)	p
Sex			
Male (n=26)	20 (59)	6 (28,5)	0.03*
Female (n=29)	14 (41)	15 (71.5)	
Age			
<4 months (n=28)	19 (56)	9 (43)	0.26
4–8 months (n=15)	10 (29)	5 (24)	
>8 months (n=12)	5 (15)	7 (33)	
Rearing System			
Free range (n=0)	0 (0)	0 (0)	-
Confined (n=55)	34 (100)	21 (100)	
Food type			
Swine feed (n=28)	17 (50)	11 (52)	0.08
Organic domestic residues (n=5)	1 (3)	4 (19)	
Mixture (n=22)	16 (47)	6 (29)	
Treated water			
Yes (n=3)	0 (0)	3 (14)	0.05*
No (n=52)	34 (100)	18 (86)	
Waterer type			
Nipple drinker (n=25)	16 (47)	9 (43)	0.77
Trough (n=30)	18 (53)	12 (57)	
Facility cleaning			
Waste removal (n=2)	0 (0)	2 (10)	0.06
Water jet (n=38)	22 (65)	16 (76)	
No removal (n=15)	12 (35)	3 (14)	
Waste disposal			
Open air (n=45)	28 (82)	17 (81)	0.89
Septic tank (n=10)	6 (18)	4 (19)	
Veterinary assistance			
Yes (n=15)	6 (18)	9 (43)	0.06
No (n=40)	28 (82)	12 (57)	
Quarantine for new animals			
Yes (n=35)	22 (65)	13 (62)	0.83
No (n=20)	12 (35)	8 (38)	
Anthelmintic use			
Yes (n=55)	34 (100)	21 (100)	-
No (n=0)	0 (0)	0 (0)	
Periodic fecal exams			
Yes (n=0)	0 (0)	0 (0)	-
No (n=55)	34 (100)	21 (100)	

*Statistically significant difference ($p \leq 0.05$) based on the chi-square test.
Source: research data.

Infection rates and parasite diversity may be influenced by the type of husbandry, sanitary management, and lack of technical assistance. Indeed, most properties included in the study utilized untreated water provided in troughs and rustic facilities, which is typical of small-scale farms. Consuming water under these conditions poses a significant risk of cross-contamination, particularly in herds with asymptomatic animals (Alencar *et al*., 2011; Pinilla *et al*., 2020; Class *et al*., 2025), a scenario directly observed and confirmed by the findings in our study.

Regarding the differential sex-related patterns of parasite infection, some previous studies have suggested that sex does not significantly influence parasite occurrence in swine (Amadi *et al*., 2018; Antunes *et al*., 2011; Li *et al*., 2022); meanwhile, others have shown that ovariectomized females have higher *A. suum* infection rates than castrated males, possibly because of sex-based differences in coprophagy (Sah, 2018; Tamboura *et al*., 2006). However, information regarding castration was not collected in our study; therefore, further investigation is re-quired to clarify the influence of sex-related factors on parasite occurrence.

Following the characterization of small-scale swine farms, management systems, and parasitic infections in the study area, we provided participating farmers with an educational booklet on swine sanitary management, specifically designed to address the gaps identified during our assessment. Additionally, we conducted individual briefings to explain property-specific results and clarify management concerns. The material covers the prevalence of gastrointestinal parasites, their economic consequences, and evidence-based prophylactic measures aimed at improving production outcomes. Considering that prophylactic strategies offer greater efficacy than intensive anthelmintic applications (Kouam; Ngueguim; Kantzoura, 2018), the implementation of sanitary management protocols is vital for optimizing productivity, ensuring herd health, and upholding food safety standards (Machado *et al*., 2022).

Finally, it is important to mention that the current data were obtained through snowball sampling, which has inherent methodological limitations. Although this technique is highly effective for accessing hard-to-reach populations, it is intrinsically non-probabilistic and susceptible to network-based biases (Johnson, 2014). Despite these limitations, we have successfully expanded current knowledge regarding the main gastrointestinal parasites affecting swine in the state of Maranhão, which is fundamental for proposing more effective control measures, especially in small-scale farms.

4 Conclusion

Our findings demonstrate that swine in São Raimundo das Mangabeiras, Southern Maranhão, Northeast Brazil, harbor a diverse range of gastrointestinal helminths and protozoa,

with infection patterns closely linked to specific husbandry systems. This study fills a significant geographical gap by representing the first investigation of swine parasites in southern Maranhão State. Thus, our data provide an important baseline for the development of targeted prophylactic measures and health interventions, particularly to enhance parasite control and production sustainability in local family-run and subsistence farms.

Acknowledgements
The Instituto Federal de Educação, Ciência e Tecnologia do Maranhão, Campus São Raimundo das Mangabeiras for the financial support to the English translation service provided by Editage.

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