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REGULAR ARTICLES

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Prevalence and risk factors associated with swine gastrointestinal nematodes and coccidia in the semi-arid region of northeastern Brazil

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Abstract

In northeastern Brazil, with has a predominantly dry climate, farmers seek alternative sources of income and livelihood by the rearing pigs. The gastrointestinal parasites that affect these animals represent an obstacle in the production and can cause significant economic loss. This study aimed to determine the prevalence and risk factors associated with gastrointestinal nematodes and Coccidia in swine herds in the Sousa microregion, Paraíba state, northeastern Brazil. This was a cross-sectional study, and the sampling was designed to determine the prevalence of endoparasite-positive farms and pigs. We randomly selected 51 farms and 187 pigs. Fecal samples were collected from each animal, and eggs per gram and oocysts per gram feces were recorded. The data collected in the epidemiological questionnaires were used to determine the possible risk factors associated with endoparasite-positive animal status. The prevalence of gastrointestinal nematodes and Coccidia in the pigs was 79.5% (149/187). Coccidia were the most prevalent parasite found, with 56.6% (106/187) of the pigs testing positive, followed by nematodes 22.9% (43/187). Strongylidae was the most common nematodes found (67.5%, 29/43), followed by *Trichuris* sp. (30.2%, 13/43) and *Ascaris* sp. (2.3%, 1/43). In 29 coprocultures, Strongylidae was identified: *Oesophagostomum* (82.2%, 25/29), *Strongyloides* (62.0%, 18/29), and *Hyostrongylus* (27.5%, 8/29). Mixed nematode and coccidial infection were observed in 72.4% (21/29) of the samples. Relevant risk factors were related to the type of management adopted by family farmers. Changes in management measures could improve the health profile of farms.

Keywords Coccidia · Nematodes · *Strongyloides* · Semi-arid · Swine culture

Introduction

Brazil is the fourth largest producer and exporter of swine meat, as it follows the requirements determined by the importing destination countries and fulfills their audit missions, with the purpose of investigating the meat-producing companies as a security guarantee in the production of the purchased meat (CONAB 2017).

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The swine sector, owing to its size, qualifies as one of the sectors responsible for the economic and social development of many Brazilian municipalities, providing access to an important source of animal protein and contributing to the employment of workers in the rural areas (ABIPECS 2013; USDA 2017).

In the northeast, swine farming is mainly characterized by family farming. The herd consists of a total of four million pigs distributed across more than 500 thousand properties. In the state of Paraíba, swine slaughter increased significantly from 2664 in 2014 to 3149 in 2015, representing an increase of 18.2% (IBGE 2015).

In the family groups, the production of the field itself and the distribution of its products reach greater participation when agriculture and livestock are compared. It is worth noting that in both types of agribusinesses (family and employer), the profitability associated with agriculture is higher, but in the case of family agribusiness, the livestock sector is more participatory due to the strong presence of poultry, swine, and cattle (Guanziroli 2007).

Livestock subsistence pigs add to the economy and contribute to local development as they easily adapt to the environment and transform food offered by the natural ecosystem into high-quality animal protein (Silva et al. 2018).

Parasites represent an obstacle in pig farming; therefore, a greater knowledge of the epidemiology of the various species that affect these animals is necessary (Góes et al. 2009). Pigs infected with gastrointestinal parasites present low food conversion rates and delays in gaining weight for the market (Hale and Stewart 1998). Infections by some parasites result in the condemnation of whole organs or carcasses, causing economic losses in the pork industry (Tomass et al. 2013).

The Sousa microregion is made up of 17 Brazilian municipalities, with a markedly negative water balance, a regional characteristic that compromises agricultural productivity throughout the year, causing farmers to seek alternatives to meet their food and economic needs. In this context, pigs are reared to provide quality protein in the diet and as a source of income to meet other family requirements. Considering these factors, this microregion was selected for this study, as it is a representative sample of the Brazilian semi-arid region, and the selected properties represent a population that survives on agriculture and pig raising as an alternative source of income in the months of low rainfall.

In the northeast, studies on the frequency and epidemiology of parasite infestations in pigs are scarce. Therefore, this research aimed to determine the prevalence of gastrointestinal parasites and characterize the type of production, management, and risk factors associated with infections in swineherds of the Sousa Paraíba microregion, Northeast Brazil.

Material and methods

Study area

The state of Paraíba has a total area of 58,584.6 km^2, 86.2% (48,788.9 km^2) of which has a semi-arid climate with annual average rainfall between 250 and 800 mm. Rainfall is irregular and usually concentrated in the months of March to May, with a maximum temperature of 32 °C and minimum temperature of 20 °C, high rates of evaporation, and relative air humidity of nearly 70%. The vegetation is predominantly of the Caatinga biome. The state is divided into four mesoregions as follows: Sertão, Borborema, Agreste, and Mata Paraibana. The Sertão is formed by the union of 83 municipalities grouped in seven microregions (Cajazeiras, Catolé do Rocha, Itaporanga, Patos, Piancó, Serra do Teixeira and Sousa) presenting an area of 22,720,482 km^2 (IBGE 2011).

The study was conducted from February to December 2018 in the Sousa microregion belonging to the Sertão mesoregion in Paraíba. From a pre-established number, 11 municipalities of this microregion were randomly selected as follows: Aparecida, Marizópolis, Nazarezinho, Paulista, Pombal, Santa Cruz, Sousa, São Francisco, São José da Lagoa Tapada, Vieirópolis, and Vista Serrana (Fig. 1).

Study design

This was a cross-sectional study, and the sampling was designed to determine the prevalence of positive properties (foci). The study was performed in two stages: (1) a pre-established number of properties (primary units) were randomly selected and (2) within the primary units, a pre-established number of pigs (secondary units) were randomly sampled.

Determination of sample size

For the calculation of the number of primary units to be sampled, the following parameters were considered: (a) expected prevalence, (b) absolute error, and (c) confidence level, according to the formula for simple random samples (Thrusfield 2007):

$$n = \frac{Z^2 \times P(1-P)}{d^2}$$

where n is number of properties sampled, Z is the value of the normal distribution for the confidence level of 95%, P is the expected prevalence of 50%, and d is the absolute error of 5%. For the fit for finite populations, the following formula was used (Thrusfield 2007):

$$n_{\text{ajus}=\frac{N\times n}{N+n}}$$

where n_{ajus} is the adjusted sample size, N is the total population size, and n is the initial sample size.

According to the State Secretariat for the Development of Agriculture and Fisheries-SEDAP/PB, the Sousa microregion has 4804 pig farms. Based on these data, a random lottery was performed to define the number of primary units to be visited, which yielded a total of 51 properties. Subsequently, from a random pre-established number, the pigs were selected accordingly; in a property with up to one pig, one was selected; up to two pigs, two were selected; and up to three pigs, three were selected. In a property that presented 4–11 pigs, 4 were selected and for properties with more than 12 pigs, 5 pigs were selected to detect the presence of parasitic infection, using the following formula (Thrusfield 2007):

$$n = \left[1-(1-p)\frac{1}{d}\right] \times \left(N-\frac{d}{2}\right) + 1$$

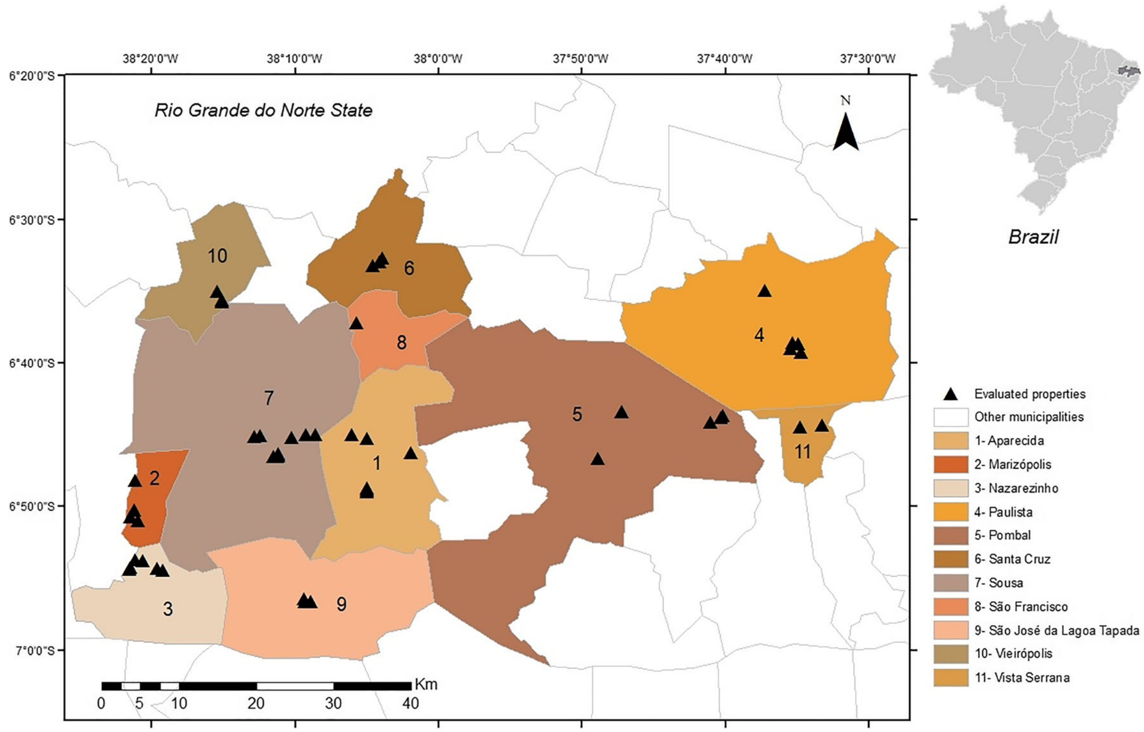

Fig. 1 Georeferencing of properties evaluated in the Sousa microregion, Sertão of Paraíba state, Brazil

where n is the sample size, p is the probability of detection of at least one infected animal, N is the size of the flock, and d is the number of infected animals in the herd. The probability of detecting at least one infection-positive animal in the herd was determined at the 95% confidence level ($p = 0.95$), and the number of positive animals per herd (d) was calculated assuming an intra-herd prevalence of 41.3% (Ahid et al. 2008). In total, 187 pigs from 51 farms were systematically sampled. The geographical coordinates of the properties visited were georeferenced as shown in Fig. 1.

Samples and sampling procedure

Fecal samples were collected directly from the rectum by use of gloves over the hands lubricated with glycerin. The samples were immediately transported to the Laboratory of Veterinary Parasitology, Instituto Federal da Paraíba, campus Sousa, where they were analyzed using the flotation technique, as described by Gordon and Whitlock (1939), to determine the level of nematode (eggs per gram (EPG)) and Coccidia (oocysts per gram (OPG)). Positive samples were cultured (coproculture), according to Roberts and O'Sullivan (1950), to determine the specific nematode genus.

To evaluate the level of infection by helminths and coccidia, the following classification was used: light (EPG or OPG < 300), mild (EPG or OPG 300–< 1000), and severe (EPG or OPG > 1000).

Determination of risk factors

In the visited properties, a structured epidemiological questionnaire was used to collect information about variables that could act as possible risk factors including sex of owner and animal(s) (male or female), age of the pigs (≤ 6 months, 7–12 months, or ≥ 13 months), breeding system (extensive, intensive, or semi-intensive), type of farm, herd management, area of property, number of animals, anthelmintic strategy, observed clinical signs, and degree of schooling of the producer (illiterate, elementary, or middle school). The obtained information was inserted in an electronic form elaborated in the program Microsoft Access® and was used in the analysis of risk factors.

Data analysis

The data collected in the epidemiological questionnaires were used to analyze possible risk factors associated with endoparasite-positive animal status. A property was considered positive when it presented at least one positive animal. The analysis of risk factors was conducted in two stages: univariate analysis and multivariable analysis. In the univariate analysis, each independent variable was crossed with a dependent variable, and those that presented p value ≤ 0.20 using the chi-square test (χ^2) or Fisher's exact test were selected for multivariate analysis using multiple logistic regression (Hosmer and Lemeshow 2000). The level of significance adopted in the multiple analyses was 5%. All analyses were performed with the SPSS software for Windows, version 20.0.

Results

The prevalence of gastrointestinal parasites in the analyzed samples of pigs in the Sousa-PB microregion was 79.5% (149/187). It was also found that at least one animal was positive for these parasites in 84.3% (43/51) of the evaluated properties.

The distribution of nematode and coccidial infection among pigs and farms is present in Table 1. In the fecal examinations, the gastrointestinal parasites included 15.5% (29/187) nematodes, 56.6% (106/187) Coccidia, and 7.4% (14/187) mixed infection (*Estrongilidae* + Coccidia). The level of infection by nematodes and Coccidia is shown in Table 2. It was observed that most of the positive animals presented mild infection for both nematodes (60.4%) and Coccidia (85.8%).

Coprocultures were performed to identify the third stage larvae in 29 samples that tested positive for nematodes. All 29 samples were positive for larvae, with the genera *Oesophagostomum* being the most prevalent 82.2% (25/29), followed by *Strongyloides* in 62.0% (18/29), *Hyostrongylus* in 27.5% (8/29), and mixed infection in 72.4% (21/29) of the samples.

We analyzed the owners' information and property characteristics regarding pig management associated with the development of nematodes and Coccidia (Table 3). In the univariate analysis, categories that showed $p \leq 0.20$ for nematodes included the lack of de-worming of the animals, low education level of the owner, and non-separation of pigs by age. For coccidia, these included contact with bovines and the presence of maternity bays.

The risk factors for the occurrence of nematodes and coccidia in pigs determined by multiple logistic regression analysis are presented in Table 4.

Table 1 Distribution of nematode and coccidial infection among pigs and farms in the Sousa microregion, Paraíba state, Brazil

Parasites		Pigs		Farms	
		Positive	%	Positive	%
Nematodes	*Estrongilidae*	15	8.1	5	9.9
	Trichuris sp.	13	6.9	4	7.8
	Ascaris sp.	1	0.5	1	1.9
Coccidia		106	56.6	26	51
Estrongilidae + coccidia		14	7.4	7	13.7
Total		149/187	79.5	43/51	84.3

Table 2 Level of infection by nematodes and coccidia among pigs in the Sousa microregion, Paraíba state, Brazil

Infection	Nematode		Coccidia	
	EPG	Positives (%)	OPG	Positives (%)
Mild	≤ 300	26 (60.4)	≤ 300	91 (85.8)
Moderate	300–≤ 1000	10 (23.3)	300–≤ 1000	8 (7.5)
Severe	> 1000	7 (16.3)	> 1000	7 (6.7)
Total	–	43 (100)	–	106 (100)

EPG, eggs per gram; *OPG*, oocysts per gram

The relevant risk factors for nematode infection were the low level of schooling of the owners, lack of de-worming of the animals, and the non-separation of the pigs by age. For Coccidia, the risk factor was the presence of maternity bays.

Discussion

The high prevalence of gastrointestinal parasites in pigs observed in this study (79.5%), in association with the high percentage of properties with parasite-infected animals (84.3%), reflected the errors in the sanitary management of the studied microregion, where some factors may have favored the transmission of parasites among animals. Similar results were found in the outskirts of Itabuna-BA with pigs from family farms, revealing 70% prevalence of Coccidia in feces (*Eimeria* spp. and *Isospora suis*), 46% *Balantidium coli* cysts, 42% *Entamoeba* sp., 66% *Estrongilidae* type eggs, 22% *Ascaris suum* eggs, 10% *Macracanthorhynchus hirudinaceus* eggs, 6% *Trichuris suis* eggs, and 14% *Metastrongylus salmi*, that characterized a high diversity and prevalence of gastrointestinal parasites in subsistence pig breeding (Pinto et al. 2007). Karaye et al. (2016) reported a prevalence of 61.5% of gastrointestinal parasites in pigs in the state of Nasarawa, Nigeria, where agriculture is the mainstay of the local economy. According to these authors, the high prevalence recorded in the studies could be attributed to inadequate measures in pig rearing. These data reinforce the fact that parasitic diseases can be associated with precarious management measures, emphasizing that the problems with inadequate management practices are not newt, but that they continue to persist, as evidenced by the stagnation of the small producers.

The prevalence of nematodes was 22.9%. This result corroborates the findings of Souza et al. (2004) who reported a 26.67% prevalence of helminths among pigs in the metropolitan region of Recife-PE. Eggs of *A. suum* were found in one fecal sample (0.5%). The infection rate was lower than that reported by Roepstorff and Jorsal (1989) who found 66 swine herds in Denmark showed an 88% prevalence of *A. suum* due

Table 3 Univariate analysis of risk factors associated with nematode and coccidial positivity among pigs in the Sousa microregion, Paraíba state, Brazil

Variable/category	Total pigs	Nematode		Coccidia	
		No. of positives (%)	*p* value	No. of positives (%)	*p* value
Sex of the owner					
Male	153	37 (24.2)		89 (50.0)	
Female	34	6 (17.6)	0.146*	17 (57.4)	0.446
Level of schooling					
Illiterate	34	14 (41.2)		17 (50.0)	
Elementary and middle school	153	29 (18.9)	0.027*	89 (58.2)	0.446
Floor					
Earth	95	33 (34.7)		52 (54.70)	
Cement	92	10 (10.8)	0.006*	54 (58.7)	0.658
Cleaning of premises					
Yes	114	18 (15.8)		60 (52.6)	
No	73	25 (34.2)	0.032*	46 (63.0)	0.213
De-worming					
Yes	145	23 (15.8)		23 (40.5)	
No	42	20 (47.6)	0.004*	83 (58.5)	0.488
Separated by age					
Yes	142	22 (15.5)		23 (51.1)	
No	45	21 (46.6)	0.002*	83 (58.5)	0.488
Performed quarantine					
Yes	145	34 (23.4)		87 (60.0)	
No	42	9 (21.4)	0.100*	19 (45,2)	0.128*
Maternity bays					
Yes	139	22 (15.8)		85 (61.2)	
No	48	21 (43.7)	0.005*	21 (43.8)	0.007*

*Variables that presented a value of $p \leq 0.20$ by the χ^2 test or Fisher's exact test

to the traditional management of the herd with overcrowding, poor hygiene, and poor de-worming programs. However, our findings are in agreement with those of the studies performed by Ruiz et al. (2016) in Minas Gerais and São Paulo showing 1.6% and 3.5% positivity in swine feces, respectively. Although the lack of hygiene and efficient de-worming programs were identified in the present study, there was no overcrowding.

There was a high prevalence of animals that tested positive for enteric coccidia (56.6%). These results differ from those reported by d'Alencar et al. (2006) in the Camaragibe municipality, Pernambuco, where coccidial oocysts were detected in 1.6% (18/1126) of the analyzed samples. This difference may be related to the type of breeding, since d'Alencar used samples of pigs from eight farms and three subsistence farms. This difference between

Table 4 Multivariate analysis of risk factors for nematode and coccidial infections among pigs in the Sousa microregion, Paraíba state, Brazil

Risk factors	CR	EP	Wald	Odds ratio	95% CI	*p* value
Nematode						
Low level of schooling	1.071	0.503	4.540	2.919	1.090–7.818	0.033
Not de-worming animals	1.734	0.499	12.082	5.666	2.131–15.066	0.001
Not separating pigs by age	1.722	0.490	12.326	5.594	2.139–14.626	0.001
Coccidia						
Presence of maternity bays	0.998	0.368	7.337	2.712	1.318–5583	0.007

CR, regression coefficient; *EP*, standard error; *CI*, confidence interval the values demonstrates that with adequate measures and technical investment, it is possible to decrease the prevalence of Coccidia and consequently improve profits.

Among the parasite-positive animals, there was a predominance of mild, subclinical infections for both nematodes and Coccidia. Monetary losses due to subclinical parasitic infections are believed to be high, but difficult to quantify. According to Aguiar (2009), subclinical infections are important and can be frequent, affecting animals by causing loss of appetite, low weight gain, and reduced food conversion. In this study, it was observed that the rates of subclinical infections are high in the region and that the loss goes unnoticed by most producers. The absence of clinical signs compromises the treatment and the infections remain in the properties, causing economic loss.

On analyses of the coprocultures, it was verified that the genus *Oesophagostomum* was the most prevalent (82.2%; 25/29), followed by *Strongyloides* (62.0%; 18/29) and *Hyostrongylus* (27.5%; 8/29). Different prevalence rates were reported by d'Alencar et al. (2006) who analyzed 1065 porcine samples from Camaragibe, Pernambuco and identified the prevalence of the genera *Hyostrongylus* as 1.88% (20/1065) and that of *Trichostrongylus* as 0.56% (6/1065). The genus *Oesophagostomum* was the most prevalent swine nematode in small farms in Tanzania (Esrony et al. 1997). The high prevalence of this genus can be attributed to its high egg excretion rate and precarious hygiene conditions, which are common in most of the systems of pig production in East African countries that resemble those found in the region studied here (Nissen et al. 2011). According to Roepstorff et al. (1996), this parasite has a completely different life strategy from other nematodes that infect swine, where almost all larvae become mature and remain inside the host longer than other nematodes, ranging from 2 to 4 months.

The most relevant risk factors for nematode infection were the lack of de-worming procedures for animals, non-separation of pigs by age, and low level of education of the owners. Similar risk factors were reported by Roesel et al. (2017), who associated the presence of gastrointestinal helminths with inadequate management practices related to sanitation in central and eastern Uganda. Additionally, Chilundo et al. (2017) evaluated the prevalence and risk factors of endo- and ectoparasitic infections in pigs in Mozambique and reported that pigs on farms of smallholders were infected by high parasitic loads in six villages. A low level of education of the residents (INE 2007) was observed. A case-control study of pathogens involved in piglet diarrhea in the state of São Paulo, Brazil. Ruiz et al. (2016) observed only two farms (2/52) and 3.8% of the samples were nematode positive. This information suggests that it is possible to control helminthic infections through the correct use of anthelmintic drugs and suitable facilities with better hygiene measures. The adoption of appropriate management practices can disrupt the transmission cycle of the parasites.

The presence of maternity bays should be effective in reducing coccidian infections, but this factor was marked as a risk factor in this study for the development of these parasites. It was observed that the farmers did not perform adequate cleaning of the bays with disinfectant solutions and did not remove the excreta daily, which led to the infection in the pigs. It is necessary to associate the presence of maternity bays with adequate hygiene measures to aid in the control of coccidiosis.

According to Qing et al. (2013), the agricultural management system is a risk factor for the high prevalence of endoparasites in pigs in the Shaanxi province, China. The high prevalence of nematodes and Coccidia reported in this study could be due to poor facilities, coupled with the low level of technical knowledge of the producers, and lack of hygiene in the facilities. Due to the frequent fecal-oral cycle, direct and prolonged contact with feces is the main method of infection by endoparasites.

The Sousa microregion has a scarce rainfall, preventing family farmers from having a guaranteed income from grain production throughout the year. In this study, it was observed that pig rearing, as a source of primary or secondary income, is a common alternative occupation in the rural properties, ensuring that the rural producers remain in the field during the months of greatest agricultural difficulty. The high diversity and prevalence of gastrointestinal parasites found in this research identify a problem that may compromise the profitability inherent in the production of these animals.

Conclusion

It was concluded that the prevalence of gastrointestinal parasites, particularly Coccidia and nematodes, in pigs raised in a family farming system in the Sousa-PB microregion is high. The relevant risk factors for nematodes included the low education level of the owners, lack of de-worming of animals, and non-separation of pigs by age, whereas, for Coccidia, it included the presence of maternity bays on the farm was a relevant risk factor. Changes in management measures could improve the health profile of farms.

Compliance with ethical standards

Ethical standards The experiments conducted in this work comply with current laws in Brazil, being approved by the Research Ethics Committee of Instituto Federal da Paraíba, protocol number: 23000.001403.2018-17.

Conflict of interest The authors declare that they have no conflict of interest.

References

Aguiar, CIAC., 2009. Aspectos epidemiológicos das parasitoses gastrintestinais de suínos naturalizados de criações familiares do Distrito Federal, (Dissertação, Universidade de Brasília, Brasília)

Ahid, SM., Suassuna, AC., Maia, M., Costa, V., & Soares, H, 2008. Parasitos gastrintestinais em caprinos e ovinos da região oeste do Rio Grande do Norte, Brasil, Ciência Animal Brasileira, 9(1), 212–218; Recuperado de https://www.revistas.ufg.br/vet/article/view/3681

Associação Brasileira da Indústria Produtora e Exportadora de Carne Suína - ABIPECS, 2013. In: Disponível em: http://www.abipecs.org.br/uploads/relatorios/relatoriosassociados/ABIPECS_relatorio_2011_pt.pdf , Relatórios Anuais da Abipecs, Acesso em 22 nov 2018

Chilundo, AG., Mukaratirwa, S., Pondja, A., Afonso, S., Miambo, R., Johansen, MV, 2017. Prevalence and risk factors of endo- and ecto-parasitic infections in smallholder pigs in Angónia district, Mozambique, Veterinary Parasitology: Regional Studies and Reports 7, 1—8, https://doi.org/10.1016/j.vprsr.2016.11.008

Companhia Nacional de Abastecimento- CONAB, 2017. In: file:///C:/Users/Usu%C3%A1rio/ Downloads/ Carne_Suina_-_Analise_Mensal_-_dezembro 2017, Acessed in October, 25, 2018

D'Alencar, AS., Faustino, MA da glória., Sousa, DP., Lima, MM., Alves, LC, 2006. Infecção Por Helmintos E Coccídios Em Criação De Suínos De Sistema Confinado Localizada No Município De Camaragibe-Pe Infection By Helmints and Coccidia in Confined Swine From the District of Camaragibe – Pernambuco State – Brazil, Ciência Veterinária nos Trópicos, 9, 79–86

Esrony, K., Kambarage, DM., Mtambo, MMA., Muhairwa, AP., Kusiluka, LJM, 1997. Helminthosis in local and cross-bred pigs in the Morogoro region of Tanzania, Preventive Veterinary Medicine, 32, 41–46. https://doi.org/10.1016/S0167-5877(97)00011-1

Gordon, HM., Whitlock, HV, 1939. A new tecnique for counting nematode eggs in sheep faeces, Journal of Scientific Research, 12, 50–52

Góes, G., Tarcísio, DB., Santos, B, 2009. Ocorrência de enteroparasitas em amostras fecais de suínos do município de Simão Dias-SE, Caderno de Graduação - Ciências Biológicas e da Saúde. https://periodicos.set.edu.br/index.php/cadernobiologicas

Guanziroli, CE, 2007. Dez anos depois: resultados e perspectivas para o desenvolvimento rural, Revista de Economia e Sociologia Rural, 45, 301–328. https://doi.org/10.1590/s0103-20032007000200004

Hale, OM., Stewart, TP, 1998. Losses to internal parasites in swine production, Journal of Animal Sciences, 66, 1548–1554

Hosmer, DW., Lemeshow, S, 2000. Applied logistic regression, New York, John Wiley e Sons, 375pp

Instituto Brasileiro de Geografia e Estatística. 2015. Produção Pecuária-IBGE, In: https://biblioteca.ibge.gov.br/visualizacao/periodicos/2380/epp_2015_1tri.pdf , Acessed in: March, 22, 2019.

Instituto Brasileiro de Geografia e Estatística- IBGE, 2011. Censo demográfico população de habitantes, In: https://www.ibge.gov.br/estatisticas/sociais/populacao.html, Acessed in June, 26, 2018

Instituto Nacional de Estatística – INE, 2007. Estatísticas do Distrito de Cidade De Tete, Acesso em 04 Ago 2010 e Ine, 2010. In: Chipembe, CS., Maunze, XH., Duce, P., Alfeu, H., Mangue, J., Muchanga, I. (Eds.), III - Recenseamento geral da população e habitação: Indicadores sociodemográficos distritais - Província de Tete. Instituto Nacional de Estatística; Acesso disponível em: http://www.tete.gov.mz/informacao/estatistica/resultados_censo_2007.pdf

Karaye, G., Iliyasu, D., Dogo, A., Madu, H, 2016. Prevalence of Swine Gastrointestinal Parasites in Four Selected Local Government Areas of Nasarawa State, Nigeria, International Journal of Livestock Research, 6, 21, https://doi.org/10.5455/ijlr.20151217082323

Nissen, S., Poulsen, IH., Nejsum, P., Olsenm, A., Roepstorff, A., Rubaire-Akiiki, C., et al, 2011. Prevalence of gastrointestinal nematodes in growing pigs in Kabale District in Uganda, Tropical Animal Health and Production, 43, 567–572. https://doi.org/10.1007/s11250-010-9732-x

Pinto, JMS., Costa, JO., Souza, JCA, 2007. Ocorrência de endoparasitos em suínos criados em Itabuna, Bahia,Brasil, Ciência Veterinária nos Trópicos, v. 10, n. 2, p. 79–85

Qing, L., XingYe, W., MeiMei, C., WanXin, R., Bing, H., WenYu, C., et al, 2013. Epidemiological investigation on swine intestinal parasites in Shaanxi province, China, African Journal of Microbiology Research, 7, 4251– 4256, https://doi.org/10.5897/AJMR12.812

Roberts, FHS., O'Sullivan, PJ, 1950. Methods for egg counts and larval cultures for strongyles infecting the gastro-intestinal tract of cattle, Australian Journal of Agricultural Research, v.1, p. 99–102, https://doi.org/10.1071/AR9500099

Roepstorff, A., Jorsal, SE, 1989. Prevalence of helminth infections in swine in Denmark, Veterinary Parasitology, 33, 231–239, https://doi.org/10.1016/0304-4017(89)90133-7

Roepstorff, A., BjØrn, H., Nansen, P., Barnes, EH., Christensen, CM, 1996. Experimental Oesophagostomum dentatum infections in the pig: Worm populations resulting from trickle infections with three dose levels of larvae, International Journal for Parasitology, 26, 399–408, https://doi.org/10.1016/0020-7519(96)00006-9

Roesel, K., Dohoo, I., Baumann, M., Dione, M., Grace, D., Clausen, PH, 2017. Prevalence and risk factors for gastrointestinal parasites in small-scale pig enterprises in Central and Eastern Uganda, Parasitology Research, 116, 335–345. https://doi.org/10.1007/s00436-016-5296-7

Ruiz, VLA., Bersano, JG., Carvalho, AF., Catroxo, MHB., Chiebao, DP., Gregori, F., et al, 2016. Case-control study of pathogens involved in piglet diarrhea, Veterinary Research, BMC Res. Notes 9, 1–7. https://doi.org/10.1186/s13104-015-1751-2

Silva, YL., Gamarra-Rojas, G., Fernandes, FÉP., Farias, JLS., Fernandes, CS, 2018. A produção animal na economia da agricultura familiar : Estudo de caso no semiárido brasileiro, Cadernos de Ciência & Tecnologia, 35, 53–74

Souza, ACM., Sousa, DP., Neves, MLMW., et al, 2004. Freqüência de infecção por helmintos em suínos de criatórios urbanos da região Metropolitana de Recife – PE, In: Jornada de ensino, pesquisa e extensão, Recife. Anais... ,Recife, UFRPE. 2004. 1 CD-ROM

Thrusfield, M, 2007. Veterinary Epidemiology, https://doi.org/10.1016/B0-72-169777-1/50023-8

Tomass, Z., Imam, E., Kifleyohannes, T., Tekle, Y., Weldu, K, 2013. Prevalence of gastrointestinal parasites and *Cryptosporidium* species in extensively managed pigs in Mekelle and urban areas of southern zone of Tigray region, Northern Ethiopia, Veterinary World, 6, 433–439, https://doi.org/10.5455/vetworld.2013.433-439

United States Department of Agriculture – USDA, 2017. Livestock and Poultry: World Markets and Trade. In: https://downloads.usda.library.cornell.edu/usda-esmis/files/73666448x/j96021035/fb494886q/livestock-poultry-ma-10-12-2017.pdf. Accessed 12 February 2019