

# Prevalence and risk factors of gastrointestinal parasites in backyard pigs reared in the Bucaramanga Metropolitan Area, Colombia

## Prevalência e fatores de risco de parasitos gastrointestinais em suínos criados na Área Metropolitana de Bucaramanga, Colombia

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### Abstract

Backyard pigs have been associated with poor sanitary conditions and the development of parasitic diseases, often causing public health and food safety problems. Therefore, the aim of this study was to determine the prevalence and risk factors for gastrointestinal parasites in backyard pigs. 279 animals were sampled from thirty-two backyard pig farms located in the Bucaramanga, Floridablanca, Giron and Piedecuesta municipalities, from Bucaramanga Metropolitan Area, Colombia. Fecal samples were taken directly from the rectum and processed by four coprological techniques. The overall prevalence of gastrointestinal parasites was 91%, being the highest values for *Balantidium coli* and *Eimeria* sp. Regarding the prevalence by municipalities, there was no statistical association ( $p \geq 0.05$ ) indicating that the prevalence was similar in the region under study. Floridablanca municipality, free-ranging pigs, access to latrines, and consumption of spring water showed to be a risk factor for nematodes, while Giron municipality, pigs > 7 months of age and access to latrines, increased infection risk for coccidian. We concluded that there is a high prevalence of gastrointestinal parasites in backyard pigs from the Bucaramanga Metropolitan Area, and that it could be controlled by improving management practices and farm facilities.

**Keywords:** Backyard pigs, gastrointestinal parasitism, nematodes, protozoan.

### Resumo

Suínos criados em fundo de quintal têm sido associados às más condições sanitárias e ao desenvolvimento de doenças parasitárias, frequentemente causando problemas de saúde pública e segurança alimentar. Assim, o objetivo deste estudo foi determinar a prevalência e os fatores de risco para parasitos gastrointestinais em suínos criados em fundo de quintal. Foram amostrados 279 animais de 32 fazendas de suínos localizadas nos municípios de Bucaramanga, Floridablanca, Giron e Piedecuesta, da Área Metropolitana de Bucaramanga, Colômbia. As amostras fecais foram coletadas diretamente do reto e processadas por quatro técnicas coprológicas. A prevalência geral de parasitos gastrintestinais foi de 91%, sendo os maiores valores para *Balantidium coli* e *Eimeria* sp. Em relação à prevalência por municípios, não houve associação estatística ( $p \geq 0,05$ ), indicando que a prevalência foi semelhante na região estudada. O município de Floridablanca, porcos caipiras, acesso a latrinas e consumo de água da nascente mostraram ser um fator de risco para os nematoides enquanto no município de Giron, porcos com mais de 7 meses de idade e acesso a latrinas, aumentou o risco de infecção por coccídios. Concluiu-se que há uma alta prevalência de parasitos gastrointestinais em suínos criados em fundo de quintal da Área Metropolitana de Bucaramanga, e que isso poderia ser controlado melhorando as práticas de manejo e as instalações agrícolas.

**Palavras-chave:** Porcos caipiras, parasitismo gastrointestinal, nematóides, protozoários.

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## Introduction

Gastrointestinal (GI) parasitism is caused by different genera of parasites that inhabit the digestive tract of pigs, causing several digestive signs, loss of appetite, poor growth rate, poor feed conversion ratio, organ and carcass condemnation, high cost of treatment, economic losses in the farms, and even death in severe cases (Kagira et al., 2012). Therefore, parasites represent an obstacle in swine production, and thus, greater knowledge about the epidemiology is necessary (Góes et al., 2009). In general, GI parasitism in pigs is caused by nematodes and protozoan (Cordero & Rojas, 1999). Protozoan, *Eimeria* sp. and *Cystoisospora suis*, are enterococcidia which causes swine coccidiosis, an infection characterized by diarrhea in pigs under three months of age; also, parasitic infections by nematodes such as *Ascaris suum*, *Trichuris suis*, *Strongyloides ransomi* and parasites of the Strongylida order (Cordero & Rojas, 1999). Many GI parasites affect health and swine production, and can be transmitted to humans, such as *Balantidium coli*, *Entamoeba coli* and *Cryptosporidium* sp. (Solaymani-Mohammadi & Petri, 2006). These protozoans are transmitted via the fecal-oral route in both humans and animals, usually through the ingestion of contaminated water or food (Zheng et al., 2019).

Some authors have reported parasitic prevalences in backyard pigs. Mendoza-Gómez et al. (2015) reported prevalence rates of 40% for *E. coli* and 5% for *B. coli* in semi-technified farms from Cundinamarca department, Colombia, whilst Herrera et al. (2015) reported 97.5% of GI parasitism (GIP) prevalence in Colombian creole pigs reared outdoors in the department of Cordoba. In a Mexican study, Kú et al. (2013) registered a general GIP prevalence of 71.9% in backyard pigs, whilst Cazorla Perfetti et al. (2013) found 66.4% of prevalence for protozoan and helminth parasites in pigs from a rural community in Venezuela, being *B. coli* (45.38%) the most prevalent endoparasite. In the semi-arid region of northeastern Brazil, de Araújo et al. (2019) reported 79.5% prevalence of gastrointestinal parasites, being coccidia (56.6%) the most prevalent parasite recovered, followed by parasites of the Strongylida order (8.1%). Roesel et al. (2017) conducted a study in small pig farms from Central and Eastern Uganda, Africa and reported a GIP prevalence of 61.4%, being parasites of the Strongylida order and *Eimeria* sp. the most prevalent parasites.

In our country, pig farming is a technified industry that supplies the national market; however, backyard pig farming systems have been an alternative to generate economic income in many families in different regions of the country. The Santander department is located in the Colombian Northeast. This region is characterized by agricultural and cattle livestock production. According to the Colombian Agricultural Institute (ICA) the swine population census for the department was 93,000 pigs, being 85% in backyard and 30% located in the Bucaramanga Metropolitan Area (ICA, 2017). Generally, this system is associated with a low socio-cultural and human health status, poor facilities, absence of veterinarian, poor sanitary conditions of the pig farms, lack of wastewater treatment, and the development of parasitic diseases in these species, often causing public health and food safety problems. In Colombia, there is little epidemiological information about GIP in pigs, especially in the Northeast region of the country, and for this reason, the aim of the present research was to determine the prevalence of GIP and risk factors in backyard pigs reared in the Bucaramanga Metropolitan Area, Colombia.

## Materials and Methods

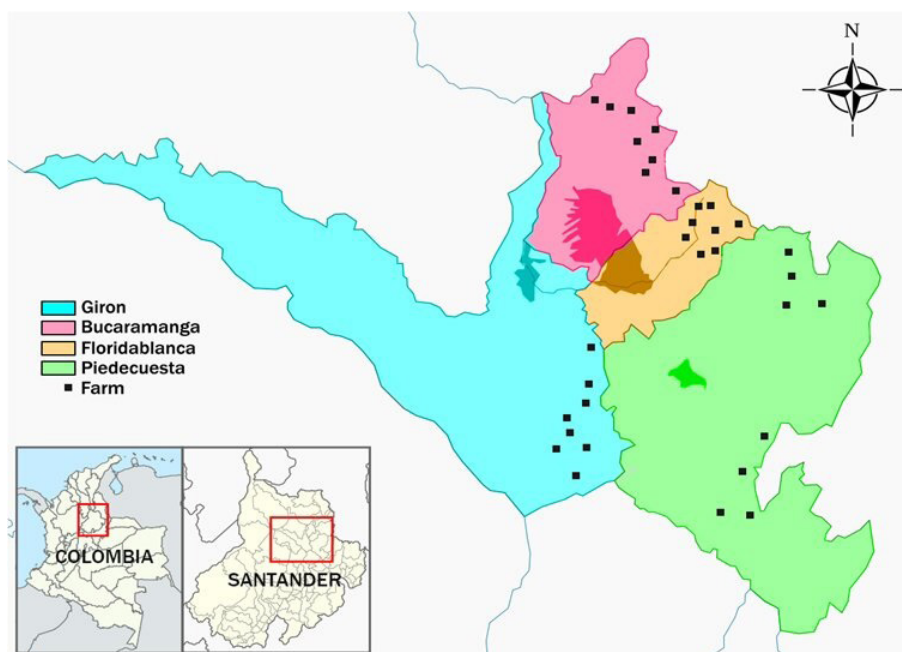
### Study area and sampling design

The research was conducted in backyard pig farms located in the Bucaramanga Metropolitan Area, department of Santander, Northeast of Colombia, which consists in four municipalities: Bucaramanga (7°07'07"N-73°06'58"W), Floridablanca (7°04'11"N-73°05'52"W), Giron (7°04'23"N-73°10'05"W), and Piedecuesta (6°59'19"N-73°03'01"W) (Santander, 2017). This region comprises a geographical area of 1,479 km<sup>2</sup>. Rainfall is regular throughout the year; however, the most of their rainfall from October to December. Bioclimatic characteristics of the region are similar and with a mean annual temperature of 25°C, with little weather variation throughout the year. Altitude is between 600 and 1700 masl and the mean annual rainfall is 1040 mm, with 78% relative humidity (Santander, 2017). Within our study area, there is abundant evidence of backyard pig farms, as illustrated in Figure 1.

A random study, descriptive and transversal, was designed. Based in the ICA's vaccination records (ICA, 2017), the farms were selected for the study using a random number table method based on the geographic location. Thirty-two backyard pig farms were visited between September and December 2019 (wet period). Figure 2 shows the Bucaramanga Metropolitan Area, department of Santander, and the location of the farms surveyed (black dots). Most of the pigs sampled were cross-breeds between the Yorkshire, Landrace and Pietrain breeds.



**Figure 1.** Backyard pigs group raised in open-air pens on farms located at the Bucaramanga Metropolitan Area, department of Santander, Colombia.



**Figure 2.** Bucaramanga Metropolitan Area map showing the locations of the farms surveyed (black dots). Bottom left shows Santander department and Colombia.

Approximately 5 -10 g of feces were collected weekly from the rectum of each pig, using previously labeled sterile polyethylene bags. In suckling piglets, a swab was introduced rectally to collect a small fecal sample. Samples were placed into containers filled with ice packs and immediately transported to the laboratory for processing. Using the formula for known populations (Thrusfield, 2007), with an expected prevalence of 50% (Pulido-Villamarín et al., 2013), and a confidence level of 95% with 6% of associated maximum error, an estimated sample size of 266 fecal samples was required to estimate the gastrointestinal prevalence of parasites in backyard pigs in this region. Fecal samples were collected by proportional affixation of total sample according to the inventory from each examined farm. Therefore, the range was between 4 to 20 samples per farm, with an average of 8.7, providing samples from 279 pigs. The number of pigs to be sampled by sex was defined by a 2:1 ratio (female: male), whilst it was considered a 25% ( $\pm 5\%$ ) frequency of the total sample for each age group.

## Risk factors

Epidemiological data about potential risk factors were obtained using a questionnaire administered to the owner or manager of each herd at the time fecal samples were collected. This data in the questionnaire included: municipality where the farm is located, age group of the examined animals ( $\leq 2$  months, 3-6 months, 7-12 months, and  $\geq 13$  months), sex, i.e. male and females, pigs free-ranging, location of the farm, the quantity of animals of the farm, pig access to latrines, de-wormed, type of feed supplied to the pigs and water source for the animals.

## Laboratory analysis

Some of the fecal material was immediately processed for direct examination with lugol's iodine solution (1:5 dilutions) to determine *B. coli* and *E. coli* cysts, as described by Rodríguez-Vivas (2015). Then, all fecal samples were cultured at room temperature, as described by Pinilla & Da Silva (2019). A centrifugation-flotation technique and McMaster technique were then used according to Pinilla & Da Silva (2019) and Sandoval et al. (2011), respectively. The numbers of opg (oocysts per gram of feces) and epg (eggs per gram of feces) on the McMaster slides were calculated with a detection level of 100 (one chamber) which is the standardized factor for this technique. The intensity of infection was determined as indicated by Sandoval et al. (2011). Finally, the Kinyoun technique was employed to detect *Cryptosporidium* sp. oocysts, as described by Rodríguez-Vivas (2015). The parasitic species observed were identified by the morphology of their eggs and oocysts using a light optical microscope with a magnification of 40 and 100x (Rodríguez-Vivas, 2015).

## Data analysis

The information obtained through the coprological techniques and epidemiological questionnaires were stored in a database that was created using the Microsoft Excel software. The GIP prevalence was determined by dividing the number of positive animals between the total animal populations of the sampled population. The results obtained were analyzed by descriptive statistics and the Chi square test ( $X^2$ ). Predictor variables with p-value  $\leq 0.05$  in the Chi-square test (Hosmer & Lemeshow, 2000) were selected for multiple analysis using logistic regression with confidence intervals (95% confidence level). The level of significance for the analyzes was 5%. Calculations were made using the SPSS v.20.0 software (© 2011 IBM corporation, United States)

## Ethical statement

The present study was approved by the Ethics Committee of the University of Santander, under initiation act no. CIF0311-19.

## Results

The overall prevalence of GIP in the Bucaramanga Metropolitan Area was 91% (254/279). No statistical association was found ( $X^2 = 0.76$ ;  $p \geq 0.05$ ) between prevalence values in the four municipalities: 89.2% (83/93) in Bucaramanga, 91.5% (43/47) in Floridablanca, 91.1% (72/79) in Giron and 93.3% (56/60) in Piedecuesta. With regard to the farms, at least one pig was positive for GIP on each examined farm, with 71.9% of farms positive to nematodes and 100% to protozoan.

Table 1 shows the 9 parasite species found in the study, being *B. coli*, *Eimeria* sp., *E. coli*, and parasites of the order Strongylida being the most prevalent. With concerning to intensity of infection, *S. ransomi* showed the highest level, followed by *A. suum*, *Eimeria* sp. oocysts and *T. suis*. *Cryptosporidium* sp. oocysts were not counted. No clinical signs of parasitic infection were observed in examined pigs. In most (78.1%) of the fecal samples examined, two or more parasite genus were evidenced, whilst in 21.9% of the cases, just one parasite genera were found.

Table 2 and Table 3 shows the analysis of the owner's information (epidemiological data) associated with nematode and protozoan infections in backyard pigs, respectively. In the univariate analysis, most categories for nematodes parasitism showed  $p \leq 0.05$ , except for the number of pigs. Regarding coccidian infections, categories that showed  $p \leq 0.05$  were Giron municipality, pigs  $> 7$  months, the altitude at  $< 1000$  masl, and de-worming of the animals, whilst for *E. coli* were Floridablanca municipality and altitude at  $> 1000$  masl. *Cryptosporidium* sp. showed a statistical association with pig access to latrines, while *B. coli* did not show a statistical association with any category.

**Table 1.** Prevalence and intensity of gastrointestinal parasites obtained from the fecal samples of backyard pigs in the Bucaramanga Metropolitan Area, department of Santander, Colombia.

Parasite	Positive (n=279)	Prevalence (%)	Intensity of infection (opg - epg)
<b>Protozoan group</b>			
<i>Balantidium coli</i>	147	52.7	260.3
<i>Eimeria</i> sp.	140	50.2	1230
<i>Entamoeba coli</i>	94	33.7	100
<i>Cryptosporidium</i> sp.	16	5.7	*
<i>Cystoisospora suis</i>	5	1.8	357.1
<b>Nematodes group</b>			
Strongylida**	36	12.9	244.4
<i>Strongyloides ransomi</i>	12	4.3	3762.5
<i>Ascaris suum</i>	11	3.9	2150
<i>Trichuris suis</i>	5	1.8	400

\* *Cryptosporidium* sp. was not counted; \*\* as Strongylida order

**Table 2.** Association between risk factors and nematode parasitism in backyard pigs reared in the Bucaramanga Metropolitan Area.

Risk factors	Categories	N°	Positive (%)	p-value
<b>Municipality</b>	B/manga	93	64 (68.8)	0.000*
	Floridablanca	47	47 (100)	
	Piedecuesta	60	7 (11.7)	
	Giron	79	65 (82.3)	
<b>Age group</b>	≤2 months	71	54 (76.1)	0.000*
	3-6 months	49	23 (46.9)	
	7-12 months	88	67 (76.1)	
	≥13 months	71	39 (54.9)	
<b>Sex</b>	Male	107	79 (73.8)	0.02*
	Female	172	104 (60.5)	
<b>Altitude</b>	<1000	139	122 (87.8)	0.00*
	>1000	140	61 (43.6)	
<b>Free-ranging pigs</b>	No	213	117 (54.9)	0.00*
	Yes	66	66 (100)	
<b>Access to latrines</b>	No	257	161 (62.6)	0.00*
	Yes	22	22 (100)	
<b>Number of pigs</b>	<10	82	60 (73.2)	0.09
	>10	197	123 (62.4)	
<b>De-worming</b>	No	17	17 (100)	0.002*
	Yes	262	166 (63.4)	
<b>Type of food</b>	Restaurant residues	60	41 (68.3)	0.000*
	Concentrate	56	19 (33.9)	
	Mixed	163	123 (75.5)	
<b>Water source</b>	Deep well water	214	121 (56.5)	0.000*
	Spring water	65	62 (95.4)	

\*Variables that presented a value of  $p \leq 0.05$  by the Chi-square test.



**Table 3.** Association between risk factors and protozoan infection in backyard pigs reared in the Bucaramanga Metropolitan Area.

Risk factors	Categories	N°	Coccidia**		Cryptosporidium sp.		Balantidium coli		Entamoeba coli	
			Positive (%)	p-value	Positive (%)	p-value	Positive (%)	p-value	Positive (%)	p-value
<b>Municipality</b>	B/manga	93	42 (45.2)		6 (6.5)		44 (47.3)		18 (19.4)	
	Floridablanca	47	19 (40.4)		4 (8.5)		27 (57.4)		23 (48.9)	
	Piedecuesta	60	30 (50)		2 (3.3)		31 (51.7)		22 (36.7)	
	Giron	79	51 (64.6)	0.03*	4 (5.1)	0.69	45 (57)	0.55	31 (39.2)	0.002*
<b>Age group</b>	≤2 months	71	26 (36.6)		2 (2.8)		35 (49.3)		23 (32.4)	
	3-6 months	49	22 (44.9)		1 (2)		22 (44.9)		14 (28.6)	
	7-12 months	88	54 (61.4)		9 (10.2)		50 (56.8)		31 (35.2)	
	≥13 months	71	40 (56.3)	0.01*	4 (5.6)	0.13	40 (56.3)	0.47	26 (36.6)	0.8
<b>Sex</b>	Male	107	51 (47.7)		7 (6.5)		60 (56.1)		36 (33.6)	
	Female	172	91 (52.9)	0.39	9 (5.2)	0.65	87 (50.6)	0.37	58 (33.7)	0.9
<b>Altitude</b>	<1000	139	84 (60.4)		7 (5)		68 (48.9)		39 (28.1)	
	>1000	140	58 (41.4)	0.02*	9 (6.4)	0.62	79 (56.4)	0.21	55 (39.3)	0.04*
<b>Free-ranging pigs</b>	No	213	113 (53.1)		12 (5.6)		112 (52.6)		69 (32.4)	
	Yes	66	29 (43.9)	0.19	4 (6.1)	0.89	35 (53)	0.95	25 (37.9)	0.41
<b>Access to latrines</b>	No	257	134 (52.1)		12 (4.7)		133 (51.8)		88 (34.2)	
	Yes	22	8 (36.4)	0.15	4 (18.2)	0.009*	14 (63.6)	0.28	6 (27.3)	0.5
<b>Number of pigs</b>	<10	82	38 (46.3)		8 (9.8)		40 (48.8)		24 (29.3)	
	>10	197	104 (52.8)	0.32	8 (4.1)	0.06	107 (54.3)	0.4	70 (35.5)	0.31
<b>De-worming</b>	No	17	2 (11.8)		1 (5.9)		9 (52.9)		6 (35.3)	
	Yes	262	140 (53.4)	0.01*	15 (5.7)	0.9	138 (52.7)	0.9	88 (33.6)	0.88
<b>Type of food</b>	Restaurant residues	60	26 (43.3)		2 (3.3)		34 (56.7)		24 (40)	
	Concentrate	56	34 (60.7)		2 (3.6)		26 (46.4)		12 (21.4)	
	Mixed	163	82 (50.3)	0.17	12 (7.4)	0.38	87 (53.4)	0.5	58 (35.6)	0.08
<b>Water source</b>	Spring water	65	28 (43.1)		2 (3.1)		30 (46.2)		22 (33.8)	
	Deep well water	214	114 (53.3)	0.15	14 (6.5)	0.3	117 (54.7)	0.2	72 (33.6)	0.9

\* Variables that presented a value of p≤0.05 by the Chi-square test. \*\* As Coccidia (*Eimeria* sp. and *Cystoisospora suis*)

Regarding risk factors (Table 4) for the occurrence of nematodes parasitism, pigs from Floridablanca and Giron municipalities showed 41.5 (OR = 41.5, CI95% = 20.1-54.3) and 2.1 (OR = 2.1, CI95% = 1.01-4.3) times higher risk of infection, respectively. Free-ranging pigs and access to latrines showed 1.96 (OR = 1.96, CI95% = 0.8-2.34) and 1.91 (OR = 1.91, CI95% = 0.75-3.2) times higher probability for infection, respectively. Animals consuming spring water showed 15.8 (OR = 15.8, CI95% = 4.8-52.2) times higher probability for infection. For coccidian infections, pigs from Giron municipality showed 2.2 (OR = 2.2, CI95% = 1.2-4.1) times higher probability of infection, whilst animals from 7 to 12 months and ≥13 months showed 2.8 (OR = 2.8, CI95% = 1.4-5.2) and 2.3 times higher risk for coccidian infections, respectively. Those pigs with access to latrines had 4.5 times more likely to be exposed (OR= 4.5, CI95% = 1.3-15.5) for *Cryptosporidium* sp. infection

**Table 4.** Multiple analysis regression of the risk factors associated with nematode and protozoan infection in backyard pigs reared in the Bucaramanga Metropolitan Area.

Risk factors	B	E. T	Exp( $\beta$ )	CI (95%)	p-value
<b>Nematodes</b>					
Floridadablanca municipality	20.4	58.6	41.5	20.1-54.3	0.000
Free-ranging pigs (yes)	0.65	0.1	1.96	0.8-2.34	0.000
Access to latrines (yes)	0.6	0.12	1.91	0.75-3.2	0.01
Spring water	2.7	0.67	15.8	4.8-52.2	0.02
<b>Coccidia*</b>					
Giron municipality	0.8	0.3	2.2	1.2-4.1	0.01
7-12 months of age	1.01	0.33	2.8	1.4-5.2	0.002
$\geq$ 13 months of age	0.8	0.34	2.3	1.1-4.3	0.02
<b>Cryptosporidium sp.</b>					
Access to latrines (yes)	1.5	0.63	4.5	1.3-15.5	0.01

B= Estimated value B; E.T= Standard error; Exp( $\beta$ )= OR; CI= Confidence interval. \* as Coccidia (*Eimeria* sp. and *Cystoisospora suis*).

## Discussion

The GIP in pigs is considered one of the most important problems in pig farming since they causing reduce weight, organ condemnation, high morbidity in young animals and even death in severe cases (Cordero & Rojas, 1999; Kagira et al., 2012). In Colombia, there is little epidemiological information on GIP in pigs, at least in the consulted literature and for this reason, the data about the GIP in pigs are still unknown.

The prevalence of GIP found in the four municipalities were similar, since the temperature and humidity conditions in the zone, the management in most of the farms as well as the programs in the control of infectious agents are very much the same in the four municipalities (Cordero & Rojas, 1999). On the other hand, the high individual prevalence of GIP found in this study indicates the absence of hygienic and sanitary management in the examined farms, where some risk factors may have favored the dissemination and transmission of parasites among animals. The results obtained in this research agree with those reported by Kú et al. (2013) who found a prevalence of 71.9% in backyard farms in the state of Yucatan, Mexico. Furthermore, the result obtained agree with those from Cazorla Perfetti et al. (2013), who reported similar values of prevalence for protozoan and helminths in pigs from a rural community in Venezuela. Similarly, the high prevalence of GIP found in the present study, agree with the findings of Herrera et al. (2015) in Colombia, Roesel et al. (2017) in Uganda, and de Araújo et al. (2019) in Brazil, who reported 97.5%, 61.4% and 79.5% prevalence of gastrointestinal parasites, respectively.

The present study found 9 parasitic species, being protozoan infections the most prevalent. In addition, some of these protozoan (*B. coli* and *E. coli*) are zoonotic in nature and can infect humans. The results obtained in this study agree with those of Pinto et al. (2007), who reported the same number of parasitic species (9). Also, these results agree with those of Herrera et al. (2015), who reported more than 12 parasite genera in their studies. According to Cordero & Rojas (1999), mixed parasitic infections in pigs are very common in backyard pig farming, and it seems to be an indication of high environmental pollution of the pig population (Herrera et al., 2015), whilst monospecies infections are less frequent, and are registered for the effect of climate change in a given region, as well as, in hosts under intensive parasite control. In the present study, 78.1% of the pigs examined were parasitized by two or more parasite genus, whilst 21.9% had one parasite genera. This result agrees with those recorded by Cazorla Perfetti et al. (2013) and Herrera et al. (2015), who found a high degree of polyparasitism in their studies. This could be due to the fact that backyard pig rearing system allows that all age groups of animals are raised together, increasing the dissemination odds of mixed infections in all animals. Although the mean intensity of infection for *B. coli* and *E. coli* found in this study, are considered mild, a more severe infection was observed for *Eimeria* sp., *S. ransomi* and *A. suum*, however, no clinical signs were observed in the examined pigs. According to Aguiar (2009) and de Araújo et al. (2019), subclinical infections are important and can be frequent, affecting animals by causing loss of appetite, low weight gain, and reduced feed conversion.

The present study found that *B. coli* was most prevalent (52.7%), followed by *Eimeria* sp. (50.2%) and *E. coli* (33.7%). These results obtained agree with those recorded by Pinto et al. (2007), who revealed similar values of prevalence in these parasites. Similarly, the results obtained in this study agree with those reported of Cazorla Perfetti et al. (2013) and Gúzman et al. (2013), who found similar prevalence values for *B. coli* in outdoor pigs from Venezuela. However, the results obtained differ from those reported of Mendoza-Gómez et al. (2015), who found 5% of prevalence for *B. coli* in farms from Cundinamarca state, Colombia. The prevalence of *E. coli* in the present study was 33.7%, and this result agrees with those reported by Mendoza-Gómez et al. (2015), who found 40% of prevalence in pigs from Cundinamarca state. Although *E. coli* do not cause infection, their presence indicates the fecal-oral transmission in the host, which is an indicator for the general assessment of the hygiene status of the animals. The high prevalence mentioned, could be caused for the ingestion of contaminated water or food, or by immunosuppression in the animals due to factors like stress associated with overcrowding.

In relation to *Cryptosporidium* sp. the prevalence rate found was 5.7% (16/279). This result agrees with those of Mendoza-Gómez et al. (2015), who found similar prevalence values in semi-technified farms. *Cryptosporidium* sp. infections are common in pigs and have been found in all age groups worldwide. Although the age distribution of *Cryptosporidium* infection rates in pigs has not been clearly concluded, it can be assumed that the prevalence in pigs aged 1–2 months is greater than that of other age groups by the weaning effect (Zheng et al., 2019). Cryptosporidiosis is a disease of high zoonotic importance, known as a public health problem, that affects mainly people that interact with farm animals daily. Therefore, it is important to demonstrate the presence of this pathogen with zoonotic potential, to take measures such as strengthening the breeding management of pigs and improving the sanitary control to avoid the spread of pathogens (Zheng et al., 2019).

As for the nematode groups, parasite genera grouped under the Strongylida order showed the highest prevalence values in this group (12.9%), whilst *S. ransomi* showed low prevalence (4.3%) and the frequency was moderate (18.7%). This could be since during the life cycle of *Strongyloides* sp., cutaneous and colostral transmission is possible and, poor hygiene conditions in the farms favor a greater risk of infection of the pigs. The prevalence of *A. suum* (3.9%) and *T. suis* (1.8%) were low. These results could be due to the fact that the pig can develop an immune response to these parasites, however, residual loads may remain in the infected animals (Murrell, 1986; Kringel & Roepstorff, 2006; Nejsun et al., 2009; Nwafor et al., 2019).

Regarding risk factors associated with gastrointestinal nematodes, backyard pigs from Floridablanca municipality had a 41.5 (OR = 41.5;  $p \leq 0.05$ ) times higher risk of infection than other locations. This municipality is located at medium altitudes (1000 to 1700 masl), with mean annual temperature (25 to 30 °C) long the year, with prolonged periods of rain and average precipitation rates between 1100 and 1400 mm, which are favorable climatological conditions for the presence of GIP and increased risk of infection for the animals. Free-ranging pigs and access to latrines showed to be a risk factor for nematode infection. These results agree with those reported by Thomas et al. (2013), who found a positive correlation between the *Ascaris* sp. infection and the interacting with latrines, and a moderate positive correlation between coccidia infection and home range area. Probably, pigs free-ranging when have access to latrines could have higher contact with paratenic hosts as earthworms or scarabaeus, and therefore, increase the parasitic disease transmission risk to the pig itself and, to other wild and domestic animals, even humans (Thomas et al., 2013).

The consumption of spring water showed 15.8 times increased risk of infection for gastrointestinal nematodes. A study conducted by Morales et al. (2015) revealed that most of the backyard pig farming had no solid effluents treatment, since they keep them inside or outside the farm, causing serious problems of spring water contamination, flies and pathogens, and a health problem for people and animals. Therefore, polluted spring water can transmit lots of pathogens with various behaviors and resistance to various environmental factors. Probably, the lack of wastewater treatment in backyard pig farming represents a serious environmental and social problems due to the contamination of the spring water and soil that are around it, which are also accompanied by swine waste odor (Morales et al., 2015).

In relation to coccidian infections, the animals raised in farms from Giron municipality had 2.2 times the risk of becoming infected than pigs from other locations. According to Cordero & Rojas (1999), *Eimeria* sp. and *C. suis* oocysts are favored by rainfall and temperature of the zone, poor facilities and poor hygiene of the farm, as well as, the high biotic potential of the coccidia. Probably, the high prevalence (64.6%) of these protozoans found in this study is associated with the wet period of the year when fecal samples were collected, since in this municipality was observed the most rainfall during the sampling period. Moreover, most of the examined farms in this municipality showed poor facilities and poor hygienic and sanitary conditions. The animals > 7 months of age showed to be a risk



factor for coccidian infections and could behave as asymptomatic carriers and act as a potential source of infection for piglets, causing eimeriosis, since they become infected by ingesting sporulated oocysts with feed or water, or by any parasitic dissemination mechanism such as people, overall, boots and intermediate host (Quiroz et al., 2011).

In our study, the access to latrines showed to be a risk factor (OR= 4.5;  $p \leq 0.05$ ) for *Cryptosporidium* sp. in pigs, since this pathogen is transmitted via the fecal-oral route in humans and animals, usually through the ingestion of contaminated water or food with feces (Chacín-Bonilla et al., 2008). Probably, the contact with infective human fecal material by pigs is an important requisite for the successful maintenance of the parasite lifecycle, therefore, it would be to think stands to reason that keeping free-ranging pigs in contact with latrines, it would increase the risk of the pigs in acquiring this infection, as in other parasitic infections (Thomas et al., 2013). In developing countries, the environmental risk factors and routes of transmission for *Cryptosporidium* sp. infection are not well defined. Despite the numerous surveillance studies reported, few investigations have been conducted about the source of infection. However, contamination of water supplies and infection of domestic animals, lacking adequate municipal water and sewage services, and using a field or latrine for defecation in human communities were correlated with a higher risk of cryptosporidiosis (Chacín-Bonilla et al., 2008).

## Conclusion

It was concluded that the high overall prevalence of GI parasitism reported in this study could be due to poor facilities, and lack of hygiene in the facilities. To our knowledge, the present research recorded *B. coli*, *E. coli*, and *Cryptosporidium* sp. for the first time in the region under study, and suggests the possible transmission of these parasite populations between pigs and humans thus increasing the transmission of parasites zoonotic potential. The relevant risk factors for nematodes included free-ranging pigs and consumption of spring water, while for *Cryptosporidium* sp., access to latrines was a relevant risk factor

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