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Porcine parasitic zoonosis in the Ashanti region of Ghana

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ABSTRACT

Pigs are coprophagous omnivores that feed on a wide range of food, thus making them susceptible to parasitic infections. This study aimed to examine the prevalence and diversity of gastrointestinal parasitic infections among pigs in the Ashanti Region of Ghana, kept under different management systems. A total of 400 fresh fecal samples from pigs of varying ages and sex were collected and analyzed using standard coproscopical techniques. Questionnaire interviews were used to assess management practices on the pig farms. The associations between age, breed, sex, and management systems and the prevalence of parasites were determined. The overall prevalence of gastrointestinal parasites in pigs was 88.75%, with multiple infections being more common than single infections ($p < 0.05$). Overall, thirteen (13) genera of protozoa and helminths were recovered from the pigs, including parasites of zoonotic importance to man. *Eimeria* spp. had the highest prevalence (64.5%), while the least prevalence (0.25%) was recorded for *Balantidium coli* and *Isospora* spp. Age, breed, sex, and type of management systems were not significantly associated with infections in pigs. The lack of treatment of pigs creates ideal conditions for the spread of zoonotic infections in the region.

Contribution/Originality: This paper provides data on parasites of pigs kept under different management systems. Previous studies focused on pigs kept in commercial farms.

1. INTRODUCTION

Pigs are stout-bodied, even-toed, ungulates that are reared from ancient times for food and other products. Over the last decade, the pig industry worldwide has experienced unprecedented patronage with a corresponding increment in production [1]. Currently, pork is the most widely consumed meat in the world, providing an excellent source of animal protein [2]. Pig farming serves as a revenue generating enterprise for small-scale farmers, especially in developing countries. The swine industry in these countries are, however, encumbered with religious, cultural and social constraints as well as infectious diseases [3]. Diseases caused by bacteria and viruses such as the African swine fever which is endemic in sub – Sahara Africa are mostly given the needed attention [4].

However, gastro-intestinal parasites which are equally significant are often neglected because of its apparent clinical signs. It is noteworthy that pigs can carry several intestinal pathogens which could hinder their growth, leading to substantial economic losses to livestock production [5]. Gastrointestinal parasites are known causes of intestinal ailments such as vomiting, diarrhea, enteritis, typhlocolitis, and rectal prolapse, as well as general symptoms such as anemia and lesions [6]. In Ghana, production of pigs occurs in different types of management systems. This ranges from a backyard or traditional system where pigs have little or no shelter and can move easily about, to large-scale management system where these animals are totally confined [7]. Traditional production system is commonly practiced in the country especially in peri-urban and rural areas as compared to semi and large-scale production [8]. This production system is preferred due to the ability to easily obtain free feed (waste) and relatively easy management of these animals [9]. However, poor management practices such as occasional disinfection of pens and lack of access to veterinary services are factors that make pigs susceptible to parasitic infections, thereby underutilizing the potential of this system and reducing productivity [3]. Moreover, "free-range" system which is also practiced in most parts of the country is a major contributing factor in which pigs are more likely to be exposed to parasitic infections as they scavenge for food. Since pigs are coprophagous, they tend to feed off excreta of animals and humans, thus aiding to transmission of zoonosis [10]. Several studies on the prevalence of gastrointestinal parasites in pigs have been undertaken worldwide [9, 11-14]. Some protozoan parasites, such as *Entamoeba* spp., *Giardia*, *Eimeria*, *Cystoisospora*, *Cryptosporidium*, *Balantidium coli* and helminth parasites such as *Fasciola* sp. *Trichuris* sp., Hookworm, *Strongyles*, *Stongyloides* spp., *Ascarid* spp., have been reported in pigs [15]. Pigs can also harbor well-known zoonotic parasites, including *Toxoplasma* spp., *Eimeria* spp., *Ascaris suum*, *Strongyloides ransomi* and *Trichuris suis*. The presence of these parasites in pigs causes different clinical symptoms depending on the parasite species and density [16]. In Ghana, only a few studies on porcine parasites have been conducted [11, 14, 17]. Overall prevalence of 28% [11] 76% [14] and 91% [17] were recorded in these studies respectively. Numerous variables, including the pigs' immune systems, ages, sexes, breeds, locations of the sampling sites, husbandry practices, sample sizes, and laboratory methods for faeces analysis, could be considered as causes of the differences in parasite prevalence in these researches. To the best of our knowledge, no research has been conducted on the prevalence of gastrointestinal parasites in all the management systems concurrently in Ghana. Therefore, this study seeks to investigate the prevalence of gastrointestinal parasites of pigs kept under the three management systems in selected districts/municipals in the Ashanti Region of Ghana. Detailed epidemiological data is needed for formulating and developing efficient control measures in these animals and public health.

2. MATERIALS AND METHODS

2.1. Study Areas

The study was carried out between September and December 2021 in the Ashanti Region of Ghana. The region has a population of 5,432,485 according to the 2020 census and it covers an area of 24,390 square kilometres, representing 10.2% of the land area of Ghana. It is located within the semi-deciduous humid forest zone of Ghana. This zone is characterized by bimodal rainfall pattern with an annual rainfall of 1300mm. The major rainy season (62% of total precipitation) occurs from March to July and the minor season (21% of total precipitation) from November to February. The relative humidity varies from 97% during the early morning in the wet season to as low as 20% during the late afternoon in the dry season.

2.2. Study Design

Screening of pigs of all age groups, sexes, management systems and breeds were conducted between September to December 2021. Stool samples of four hundred (400) pigs were collected in sterile containers labelled with identification data. Pig farms spread across five (5) districts/municipals in the Ashanti Region were chosen through a random sampling technique (Afigya Kwabre, Mampong, Sekyere Central, Ahafo Ano South and Atwima

Nwabiagya South). Figure 1 shows a map of the study locations. As previously described by Sharma, et al. [18] and Adhikari, et al. [19] pigs were classified into three age groups as sucklings and wearners (0 - 4 months), growers (>4 – 8 months), and adults (>8 months). The sampled pigs were of foreign breeds (Large White, Danish Landrace, Bentheim Black and White, Hampshire). Farms were categorized according to size of their sow herds as follows: traditional farms (> 100 sow herds), semi-intensive farms (100 to 400 sow herds), and industrial farms (< 100 sow herd) as described by John and Francis [20]. Overall, thirty (30) farms were selected, comprising fourteen (14) traditional farms, seven (7) semi-intensive and nine (9) large-scale farms respectively. With the informed consent of pig farmers, a semi-structured questionnaire was also used to assess the pig management practices and farmer's awareness of porcine zoonoses.

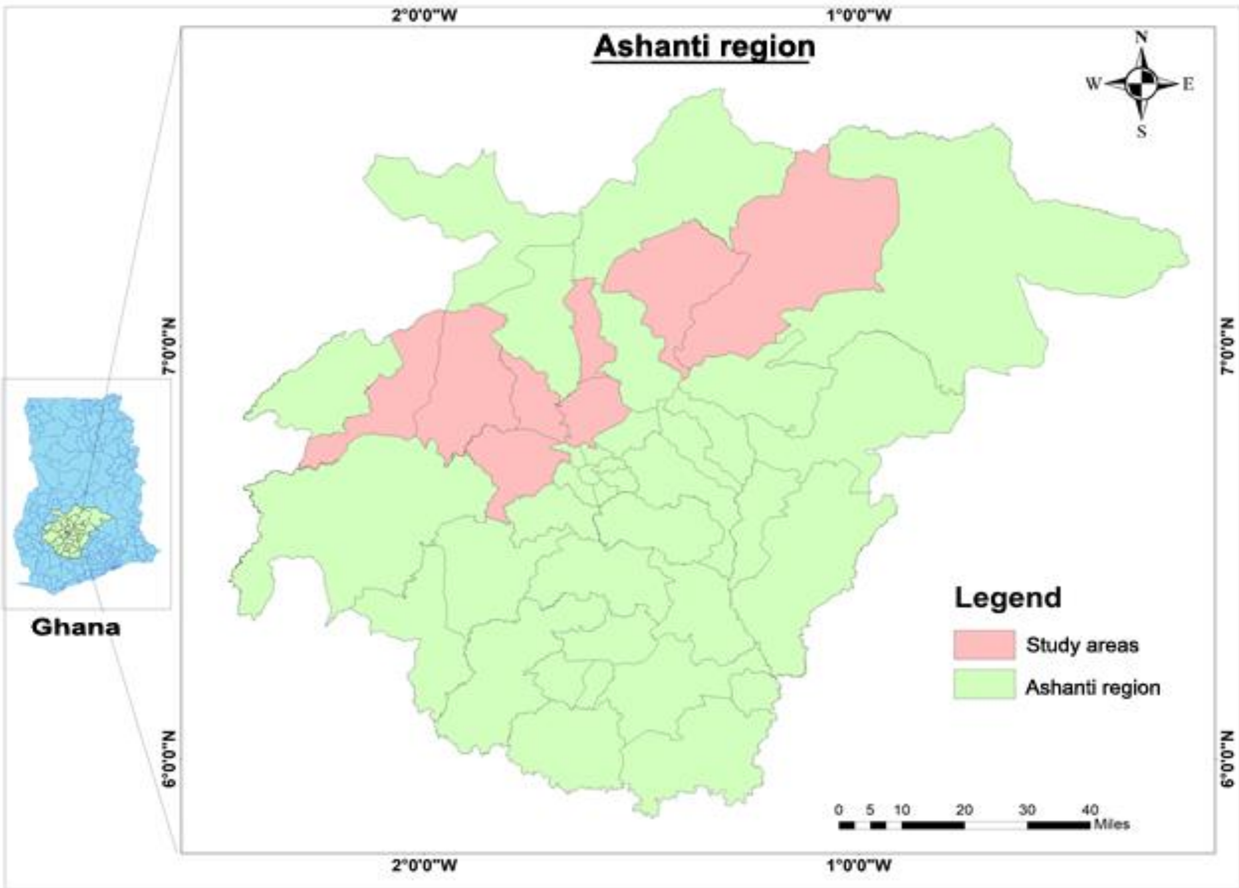

Figure 1. Sampling locations. Map was drawn using the ArcGiS version 10.

2.3. Laboratory Procedure

Flotation medium was prepared by dissolving 400g of NaCl and 500g of sugar in 1000ml of warm distilled water. About 2 to 3 grams of the fecal sample was weighed and placed in sterile plastic containers. The procedure was conducted by adding 10ml of the flotation medium to the fecal sample in a universal bottle and stirred with a rod. The mixture was then filtered through double-layered gauze into a labeled test tube to remove the fecal residue. The test tube was filled with the flotation medium until a meniscus was formed. A coverslip was placed gently on the test tube and allowed to stand on a level surface for at least 15 to 20 minutes. The coverslip was carefully removed and placed on a glass slide and examined immediately for parasite eggs under x10 and x40 magnifications, and parasitic elements were morphometrically and morphologically examined according to existing keys outlined by Soulsby [21].

2.4. Assessment of Pig Management Practices and Awareness of Zoonotic Diseases

Questionnaires were administered to the thirty (30) pig farmers who consented to be interviewed. The interviews captured information on number of pigs kept, breed(s) reared, source(s) of water and feed, knowledge of zoonosis, veterinary care and pig management practices including deworming frequency.

2.5. Data Analysis

Data was analyzed to determine frequencies and percentages using RStudio (2022.02.3 Build 492) statistical tool. Test for associations was conducted with the Chi-square ($\chi 2$) test at 5% significance level.

2.6. Ethical Approval and Consent to Owners

The Veterinary Service Directorate gave permission for this study. Individual consent from pig owners was obtained prior to collection of faecal samples and administration of questionnaires.

3. RESULTS

3.1. Prevalence and Distribution of Gastro-Intestinal Parasites in Pigs

Out of the 400-pig excrement examined, 355 (88.75%) were infested with at least one parasite. Overall, thirteen (13) parasites species were found in the feacal matter of pigs, with the top five parasites being *Eimeria* spp. (64.5%), *Ascaris* spp. (38.0%), *Strongyloides ransomi* (28.5%), *Oesophagostomum* (10.0%), and *Trichuris suis* (10.0%). Nematodes were more common than protozoans in the study pigs. The prevalence of the remaining parasites recovered were less than 4%, with a significant difference among the different species identified.

3.2. Prevalence and Distribution of Gastro-Intestinal Parasites in Relation to Sex

Female pigs recorded slightly higher prevalence (89.8%) than male pigs (86.8%), with no statistically significant difference. *Eimeria* spp. were the primary protozoa recorded in the study animals, while *Ascaris* spp. was the most predominant helminthic parasite. Save for *Strongyloides ransomi* infection which was significantly higher in females as compared to males, there was no difference in infection rates for the other parasites (Table 1).

Table 1. Prevalence and distribution of gastro-intestinal parasites in relation to sex.

Groups	Parasites	Male (N=144)	Female (N=256)	P-value
Protozoa	No. infected	125(86.81)	230(89.84)	Ns
	Eimeria spp.	94(65.28)	164(64.06)	Ns
	Entamoeba spp.	6(4.17)	6(2.34)	Ns
	Isospora spp.	0(0.00)	1(0.39)	Ns
	Balantidium coli	0(0.00)	1(0.39)	Ns
Helminthes	*Ascaris* spp.	53(36.81)	99(38.67)	NS
	Strongyloides ransomi	29(20.14)	85(33.20)	$p < 0.05$
	Trichuris suis	15(10.42)	25(9.77)	Ns
	Oesophagostomum	18(12.50)	22(8.59)	Ns
	Moniezia spp.	5(3.47)	9(3.52)	Ns
	Hyostrongylus rubidus	1(0.69)	9(3.52)	Ns
	Toxocara spp.	4(2.78)	4(1.56)	Ns
	Trichostrongylus	2(1.39)	4(1.56)	Ns
	Hookworms	2(1.39)	2(0.78)	Ns

3.3. Prevalence and Distribution of Gastro-Intestinal Parasites in Relation to Age

Among the three age groups, the highest prevalence (92.6%) was recorded in adult pigs whilst growers had the least prevalence (84.4%). *Eimeria* spp. and *Ascaris* spp. were the predominant protozoa and helminth parasites found in all age groups respectively. The infection rates of three parasite species, namely *Moniezia*, *Toxocara* and *Hyostrongylus rubidus* varied significantly with age (Table 2).

Table 2. Prevalence and distribution of gastro-intestinal parasites in relation to age.

Groups	Parasites	Sucklings and weaners (N=134)	Growers (N = 90)	Adults (N = 176)	P-value
Protozoa	No. infected	116(86.57)	76(84.44)	163(92.61)	ns
	Eimeria spp.	86(64.18)	55(61.11)	117(66.48)	ns
	Entamoeba spp.	0(0.00)	0(0.00)	1(0.57)	ns
	Isospora spp.	3(2.24)	3(3.33)	6(3.41)	ns
	Balantidium coli	0(0.00)	1(1.11)	0(0.00)	ns
Helminthes	*Ascaris* spp.	47(35.07)	30(33.33)	75(42.61)	ns
	Trichuris suis	19(14.18)	7(7.78)	14(7.95)	ns
	Strongyloides ransomi	34(25.37)	22(24.44)	58(32.95)	ns
	Oesophagostomum	20(14.93)	9(10.00)	11(6.25)	$p < 0.05$
	Trichostrongylus	2(1.49)	0(0.00)	4(2.72)	ns
	Moniezia spp.	0(0.00)	5(5.56)	9(5.11)	$p < 0.05$
	Toxocara spp.	1(0.75)	5(5.56)	2(1.14)	$p <0.05$
	Hookworms	3(2.24)	1(1.11)	0(0.00)	ns
	Hyostrongylus rubidus	0(0.00)	0(0.00)	10(5.68)	$p < 0.05$

3.4. Prevalence and Distribution of Gastro-Intestinal Parasites in Relation to Breeds

Among the breeds, the highest prevalence (100.0%) was recorded for Bentheim black and white whilst Danish landrace had the least prevalence (84.0%). The infection rates of two parasite species, namely *Ascaris* spp., and *Strongyloides ransomi*, varied significantly with breeds (Table 3).

Table 3. Prevalence and distribution of gastro-intestinal parasites in relation to breeds.

Groups	Parasites	Male (N=144)	Female (N=256)	P-value
Protozoa	No. infected	125(86.81)	230(89.84)	Ns
	Eimeria spp.	94(65.28)	164(64.06)	Ns
	Entamoeba spp.	6(4.17)	6(2.34)	Ns
	Isospora spp.	0(0.00)	1(0.39)	Ns
	Balantidium coli	0(0.00)	1(0.39)	Ns
Helminthes	*Ascaris* spp.	53(36.81)	99(38.67)	Ns
	Strongyloides ransomi	29(20.14)	85(33.20)	$p < 0.05$
	Trichuris suis	15(10.42)	25(9.77)	Ns
	Oesophagostomum	18(12.50)	22(8.59)	Ns
	Moniezia spp.	5(3.47)	9(3.52)	Ns
	Hyostrongylus rubidus	1(0.69)	9(3.52)	Ns
	Toxocara spp.	4(2.78)	4(1.56)	Ns
	Trichostrongylus	2(1.39)	4(1.56)	Ns
	Hookworms	2(1.39)	2(0.78)	Ns

3.5. Prevalence and Distribution of Gastro-Intestinal Parasites in Relation to Management System

Traditional system recorded the highest prevalence (90.4%), whilst semi-intensive management system had the least prevalence (86.3%). The infection rates of three parasite species, namely *Ascaris* spp., *Strongyloides ransomi* and *Oesophagostomum* varied significantly with management system (Table 4).

3.6. Prevalence and Distribution of Gastro-Intestinal Parasites in Relation to Location

Sekyere Central District recorded the highest prevalence (100.0%), whilst Ahafo Ano South District had the least prevalence (77.3%). The infection rates of these parasite species; *Eimeria* spp., *Isospora* spp., *Balantidium coli, Trichostrongylus* and *Oesophagostomum* did not vary significantly with location (Table 5).

Table 4. Prevalence and distribution of gastro-intestinal parasites in relation to management system.

Group	Parasites	Traditional (N = 135)	Semi – Intensive (N = 95)	Industrial (N = 170)	P value
Protozoa	No. infected	122(90.4)	82(86.3)	151(88.8)	ns
	Eimeria spp.	91(67.4)	58(61.1)	109(64.1)	ns
	Isospora spp.	0(0.0)	0(0.0)	1(0.6)	ns
	Entamoeba spp.	6(4.4)	1(1.1)	5(2.9)	ns
	Balantidium coli	0(0.0)	1(1.1)	0(0.0)	ns
Helminthes	*Ascaris* spp.	46(34.1)	29(30.5)	77(45.3)	p < 0.05
	Trichuris suis	16(11.9)	13(13.7)	11(6.5)	ns
	Strongyloides ransomi	46(34.1)	18(18.9)	50(29.4)	p < 0.05
	Oesophagostomum	16(11.9)	3(3.2)	21(12.4)	p < 0.05
	Trichostrongylus	3(2.2)	1(1.1)	2(1.2)	ns
	Moniezia spp.	5(3.7)	4(4.2)	5(2.9)	ns
	Toxocara spp.	4(3.0)	0(0.0)	4(2.4)	ns
	Hookworms	3(2.2)	0(0.0)	1(0.6)	ns
	Hyostrongylus rubidus	2(1.5)	1(1.1)	7(4.1)	ns

Table 5. Prevalence and distribution of gastro-intestinal parasites in relation to location.

Groups	Parasites	Afigya kwabre district (N = 101)	Mampong municipal (N = 96)	Sekyere Central district (N = 20)	Ahafo Ano South district (N = 66)	Atwima Nwabiagya South district (N = 117)	P value
Protozoa	No. infected	99(98.0)	78(81.3)	20(100.0)	51(77.3)	107(91.5)	ns
	Eimeria spp.	83(82.2)	37(38.5)	19(95.0)	29(43.9)	90(76.9)	ns
	Isospora spp.	0(0.0)	1(1.0)	0(0.0)	0(0.0)	0(0.0)	ns
	Entamoeba spp.	9(8.9)	3(3.1)	0(0.0)	0(0.0)	0(0.0)	p < 0.05
	Balantidium coli	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(0.9)	ns
Helminthes	*Ascaris* spp.	52(51.5)	38(39.6)	5(25.0)	21(31.8)	36(30.8)	p < 0.05
	Trichuris suis	6(5.9)	1(1.0)	3(15.0)	11(16.7)	19(16.2)	p < 0.05
	Strongyloides ransomi	49(48.5)	17(17.7)	5(25.0)	13(19.7)	30(25.6)	p < 0.05
	Oesophagostomum	14(13.9)	4(4.2)	3(15.0)	4(6.1)	15(12.8)	ns
	Trichostrongylus	1(1.0)	4(4.2)	1(5.0)	0(0.0)	0(0.0)	ns
	Moniezia spp.	2(2.0)	10(10.4)	0(0.0)	2(3.0)	0(0.0)	p < 0.05
	Toxocara spp.	0(0.0)	7(7.3)	0(0.0)	1(1.5)	0(0.0)	p < 0.05
	Hookworms	4(4.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	p < 0.05
	Hyostrongylus rubidus	7(6.9)	3(3.1)	0(0.0)	0(0.0)	0(0.0)	p < 0.05

3.7. Frequency of Single and Multiple Infections in Pigs

There was significant difference in the frequency of parasitic infection in pigs ($p < 0.05$). Multiple infections were more common (53.50%) than single infections (35.25%). The percentage of pigs harboring mixed infections of two and three was (34.25%) and (16.00%) respectively (Table 6).

Table 6. Prevalence of gastro-intestinal parasites in relation to single and multiple infections.

Infections	Number infected	Prevalence (%)	P-value
Single	141	35.25	p < 0.05
Duplet	137	34.25	
Triplet	64	16.00	
Quadriplet	12	3.00	
Pentuplet	0	0.00	
Hexuplet	1	0.25	

3.8. Age and Sex-Wise Distribution of Polyparasitism in Pigs

Table 7 shows the age and sex-wise distribution of gastrointestinal parasites in pigs. Multiple infections being more common than single infections ($p < 0.05$). However, there was no significant difference in the rate of polyparasitism infection in pigs.

3.9. Demographic Characteristics of Pig Farmers

Questionnaires were administered to thirty (30) farmers across all the farms. All farm owners were males (100%). More than half (57%) were above age 40, with 13(43%) of farmers having no formal education (Table 8).

3.10. Management Practices among farmers in the Ashanti Region of Ghana

Overall, 40% of pig farmers interviewed fed their pigs with standard pig feed and more than half (63%) fed their pigs off the bare floor (Table 9).

Table 7. Age and sex – wise distribution of polyparasitism in pigs.

Number of parasitic infestations	Suckling and weaners (N = 134)			Growers (N = 90)			Adults (N = 176)			Overall		
	Male (n=56)	Female (n=78)	P-value	Male (n=49)	Female (n=41)	p-value	Male (n=39)	Female (n=137)	P-value	Male (n=144)	Female (n=256)	p-value
Single	23(41.07)	29(37.18)	ns	18(36.73)	12(29.27)	Ns	14(35.90)	45(32.85)	ns	55(38.19)	86(33.59)	ns
Duplet	13(23.21)	26(33.33)	ns	20(40.82)	9(21.95)	Ns	23(58.97)	46(33.58)	ns	56(38.88)	81(31.64)	ns
Triplet	6(10.71)	16(20.51)	ns	5(10.20)	8(19.51)	Ns	5(12.82)	24(17.51)	ns	16(11.11)	48(18.75)	ns
Quadruplet	3(5.36)	4(5.13)	ns	0(0.00)	1(2.44)	Ns	0(0.00)	4(2.92)	ns	3(2.08)	9(3.52)	ns
Pentuplet	0(0.00)	0(0.00)	-	0(0.00)	0(0.00)	-	0(0.00)	0(0.00)	-	0(0.00)	0(0.00)	-
Hexuplet	1(1.79)	0(0.00)	ns	0(0.00)	0(0.00)	-	0(0.00)	0(0.00)	-	1(0.69)	0(0.00)	ns

Table 8. Demographic characteristics of pig farmers.

Variable		Frequency	Percentage (%)
Sex	Male	30	100.00
	Female	0	0.00
Age	<20	2	6.67
	>21 to 40	11	36.67
	>40	17	56.67
Education	No formal education	13	43.33
	Basic	7	23.33
	Senior high	6	20.00
	Tertiary	4	13.33

Table 9. Management practices in farms.

Variable	Traditional farms	Semi – intensive farms	Large-scale farms	Total	P – value
The type of feed given to pigs					
Leftovers	6	3	0	9(30.00)	
Farm products	5	2	2	9(30.00)	ns
Standard pig feed	3	2	7	12(40.00)	
Medium of feeding pigs					
On the floor	12	5	2	19(63.33)	p < 0.05
Feeding bins	2	2	7	11(36.66)	
Source of water					
Pipe – borne	4	3	4	11(36.66)	
Streams	4	2	1	7(23.33)	
Well	6	2	4	12(40.00)	ns
Disposal of feaces					
Use as manure	4	3	3	10(33.33)	
Dump in the refuse	4	2	3	9(30.00)	ns
Dump in a hole	6	2	3	11(36.66)	
Frequency of dung removal/Daily					
Once	13	5	4	22(73.33)	
Twice	1	0	2	3(10.00)	p < 0.05
Three times	0	2	3	5(16.66)	
How many times do you feed the pigs					
Once	4	1	2	7(23.33)	
Twice	8	5	6	19(63.33)	p < 0.05
Three times	2	1	1	4(13.33)	

Table 10. Farm owners' knowledge on zoonotic diseases and treatment.

Variable	Traditional	Semi–intensive	Large-scale commercial	Total	P – value
Do you employ the services of veterinary officer in your farm					
Yes	1	2	8	11(36.67)	
No	13	5	1	19(63.33)	p < 0.05
Do you deworm the pigs					
Yes	7	5	9	21(70.00)	
No	7	2	0	9(30.00)	p < 0.05
How many times a year					
Once	5	4	3	12(57.14)	
Twice	2	1	3	6(28.57)	
Three times	0	0	3	3(14.29)	p < 0.05
Anthelminthic used					
Fenbendazole	5	3	6	14(66.67)	
Ivermectin	2	2	3	7(33.33)	p < 0.05
Are you aware of transmission of parasites from pigs to humans					
Yes	2	2	5	9(30.00)	
No	12	5	4	21(70.00)	p < 0.05

3.11. Farm Owners' Knowledge on Zoonotic Diseases and Treatment

More than half (63%) of farmers did not employ the services of the veterinary officers in their farm. Regular deworming of pigs is a common practice among pig owners; however, more than half (57%) dewormed their pigs once a year and a significant proportion (70%) had no knowledge of zoonotic diseases to humans (Table 10).

Figure 2 illustrates the gastrointestinal parasites identified in the pigs.

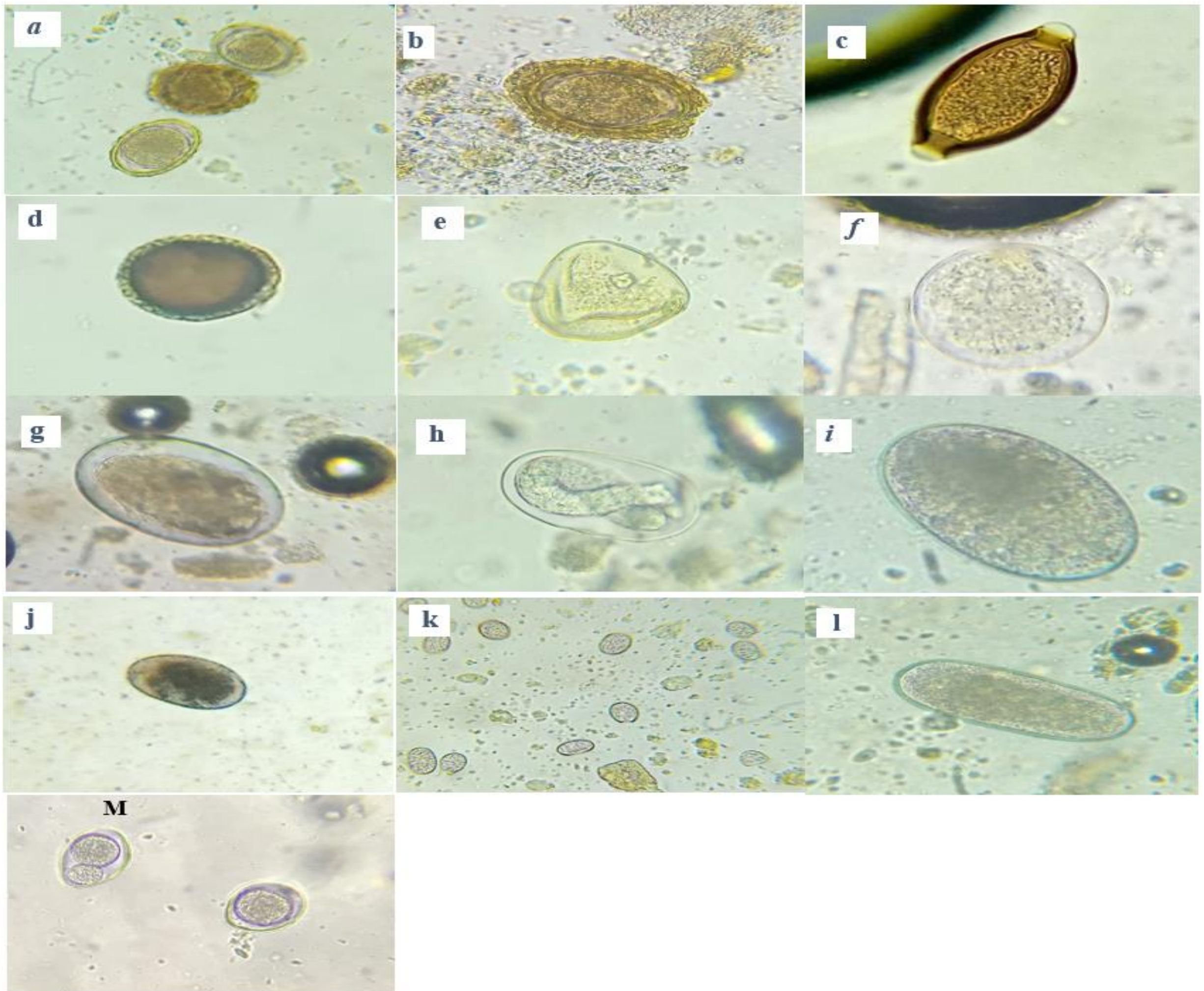

Figure 2. Gastrointestinal parasites identified in the pigs.

Note: a,b -Ascaris spp. c - Trichuris suis d - Toxocara spp. e - Moniezia spp. f - Balantidium coli g – Oesophagostomum h - Strongyloides ransomi i - Hyostrongylus rubidus j - Hookworm k - Eimeria spp. l - Trichostrongylus m - Isospora spp.

4. DISCUSSION

This study reports on diversity of gastrointestinal (GI) parasites in pigs of varying sex and age kept in the Ashanti Region of Ghana. Previous studies on pigs in Ghana were done in different locations [11, 14, 17]. All the parasites reported in this study have been recorded in pigs elsewhere, save for regional differences in parasite distribution. Out of the 400 fecal samples examined, 355 were infested with at least one parasite, thus giving an overall prevalence of 88.75%. This is slightly lower than findings in Brazil (93.1%) [22] Nepal (91%) [19] Upper East Region of Ghana (91%) [17] but higher than reports in Tanzania (83%) [1] and Ejisu in Ghana (28%) [11].

The high prevalence recorded in our study could be attributed to poor farm management practices such as feeding pigs off bare floors laden with parasite-infested excreta and irregular disinfection of pens. This practice is likely to favour transmission of soil transmitted helminthes such as *Ascaris* spp. which is environmentally robust and can persist for prolong periods. Additionally, most pigs were kept in uncemented pens with damp floors which provided conducive breeding grounds for vectors that aided in the spread of parasitic infections [23]. However, the lower prevalence recorded by Atawalna, et al. [11] (28%) was because the study reported on prevalence of gastrointestinal parasites in intensively reared hybrid pigs where most farmers practiced effective management practices in their farms, had ultra-modern facilities and relatively easy access to veterinary services unlike most farms in our report, hence the marked difference in prevalence of parasitic infection.

In most farms (63%), pigs were fed twice daily, while removal of dung from pens was done once by most farmers (73%). Since pigs were mostly fed off the floor, chances of their feed being exposed to parasite-infested excreta was very high. Moreover, pigs being coprophagous tend to feed on their feaces as they get hungry.

More than half (57%) of the farmers dewormed their pigs once a year in our study. Ivermectin or fenbendazole but not local herbs were the common anthelminthic drugs used for deworming. Even when the time of deworming was taken into account, we identified that giving anthelminthic drugs had no effect on the prevalence of gastrointestinal parasites in pigs. However, because our study only collected farmers' self-reported activities, we were unable to determine if the relevant medications were supplied at the correct dosage. This differs from a report in Nigeria [24] which discovered a negative correlation between the occurrence of intestinal parasites and routine pig deworming.

Age, breed, sex, location, and type of management systems are some risk factors that predispose pigs to parasitism. Knowledge of risk factors of infection is essential in the development of effective control programs. Identification of risk factors are however a difficult task, especially in developing countries, since less data is taken in pig farms. In this study, a higher prevalence of gastrointestinal parasites in female pigs than male pigs were observed which was in concordance with a report in Ghana [11]. Most pig farms in both reports had more female pigs than male. For breeding purposes, female pigs are relatively kept for a longer period of time and are therefore at a higher risk of being exposed to gastrointestinal parasites than males, which are generally sold off immediately they attain adulthood [8]. Furthermore, females are generally more prone to helminthic infections than males during late pregnancy and lactation. This may be attributed to hormonal changes during these times that lower their resistance to parasites resulting in the establishment of higher parasitic burdens [25, 26]. However, this differs from reports which recorded higher prevalence in males than in females [8, 11, 18, 19, 27]. The lower gastro-intestinal parasitism in females in these studies could be due to deworming practice performed by few farmers for adult pregnant pigs in pre-farrowing condition (2 weeks before farrowing). Moreover, testosterone hormones could act as an immunosuppressant [28] leading to higher chance of male pigs succumbing to helminthic infections.

There was a lower prevalence in sucklings and weaners compared to adults which could be attributed to the fact that piglets and growers are usually vulnerable and were confined in a much hygienic pens in most farms in the study area compared to adults. Piglets may have also developed immunity at birth [29]. This finding also agrees reports in Ghana [11] and India [18] but in contrast with findings in Nepal [19] which reported the highest parasitic prevalence (100%) in growers and the lowest (85%) in adult pigs. Adhikari, et al. [19] indicated that pigs after completing the weaning period, had to search for food on their own; thus, scavenge in open fields, making them susceptible to parasitic infection [19]. On the other hand, the lower prevalence of GI parasites in adult pigs could be due to greater resistance and susceptibility to reinfection due to immunity formed [30].

Our study reported higher prevalence of gastro-intestinal parasites in traditional system, than in semi-intensive and industrial management system. This is in concordance with findings in Brazil [22] and Chongqing, China [31]. In traditional management system, pigs were also kept in poorly hygienic and untidy wood – built pens which were not regularly cleaned and disinfected. Most pigs were fed off the bare floor, thus exposing them to parasitic infested excreta [32]. Moreover, education for farmers with regard to proper animal health care practices such as timely deworming of pigs with effective antihelminthic drugs was inadequate and they lack access to veterinary services.

The prevalence of GI parasites was relatively the same irrespective of the breeds of pigs. This is as a result of poor rearing conditions of pigs in the various management systems. Our findings clearly indicated that the breeds of pigs do not influence its susceptibility to parasitic infections. This is in contrary to the findings in Nigeria [33] which recorded higher prevalence of gastrointestinal parasites in indigenous pigs (100%) to foreign breeds (75%). In that study, indigenous pigs were free ranging and scavengers and mostly fed on refuse dumps, thus, making them susceptible to parasitic infections [13] compared to the foreign breeds that were kept in intensive management system with relatively effective management practices. Even though various breeds were kept in intensive management system in our study area, most farmers had less knowledge on effective husbandry management practices to be employed to curb the rate of parasitic infection in their farms.

Thirteen gastrointestinal parasites of veterinary importance, comprising four (4) species of protozoa and nine (9) species of nematode were recorded in our research. *Entamoeba* spp., *Eimeria* spp., *Ascaris* spp., *Strongyloides ransomi* and *Trichuris suis* were zoonotic parasites of public health importance to man. All the gastrointestinal parasites identified in this study have been documented worldwide.

Ascaris spp., *Balantidium coli*, *Eimeria* spp., *Strongyloides ransomi*, *Trichuris suis*, *Isospora* spp., and *Oesophagostomum* are parasites that have been recorded in Ghana [11, 17]. However, *Moniezia* spp. and *Toxocara* in pigs have not been reported in Ghana but have been reported elsewhere [34-36].

This study also revealed that *Eimeria* spp. (64.5%) was the most prevalent parasite. This finding is slightly lower than findings in Ghana (77.2%) [17] and Indonesia (78%) [37]. *Eimeria* spp. were very common in all the management systems including modern and well managed farms since they are more resistant to environmental conditions, easily survive in warm, moist environment and being very infective once they are released in faeces. They cause lesions which are related to the number of oocysts leading to diarrhea, dehydration, loss of electrolytes and perhaps death.

The only ciliated protozoan capable of infecting humans is *Balantidium coli*. It was found in 47.2% of pigs in China [38] 33.3% of pigs in Venezuela and 25% of wild boars in Iran [39]. The prevalence of *B. coli* was 0.25% in this study. In comparison to other research, the prevalence of *B. coli* is substantially lower in our report.

Ascaris spp. was the most predominant helminthic parasite. *Ascaris* spp. could be *Ascaris suum* or *Ascaris lumbricoides* which infects pigs and humans respectively. The close relationship between pigs and humans could result in a cross-species transmission [40-42] and a possible interbreeding of these two species [43, 44] thus, posing a threat to public health [14]. The prevalence of *Ascaris* spp recovered in this study was higher than the 4.9% reported from Bishoftu, Ethiopia [45] 3.7% from Turkey [46] and 17.6% from Korea [47] and 18.5% reported from Nigeria's Plateau state [48] but lower than the 54.6% and 76% reported from Botswana [49] and Ejisu in Ghana [14] respectively. The prevalence of *Ascaris* spp. is due to the fact that, these are soil transmitted helminthes and have the ability to persist for prolong periods; thus, habits like feeding off bare floor could account for this observation [50]. Pigs in traditional management systems were mostly fed off the floor contributing to a higher prevalence of *Ascaris* spp. in such farms.

This study revealed that *Strongyloides ransomi* was the second most prevalent nematode parasite after *Ascaris* spp. This is in concordance to reports in Tanzania [51] and Burkina Faso [52]. The high incidence of *Strongyloides ransomi* (28%) may be attributable to regional variances in climate conditions, management systems, and circulating parasites in a locality. Temperature and moisture in the environment are critical for the survival of *Strongyloides* larvae. These species' larvae are prone to desiccation, with arid environments offering an unfavorable condition for *Strongyloides* larvae to survive [53].

Reports from Ghana [17] Ethiopia [3, 45] Zimbabwe [54] and China [38] reported *Trichuris Suis* prevalence of 0.3%, 2.9%, 4.6%, 4.7% and 5.2% respectively, which is lower than the current study's report (10%). Studies in West Indies [55] and Uganda [54] on the other hand, reported prevalence rates of 38% and 17% respectively, which are greater than the results of this study. *T. suis* prevalence discrepancies could be attributable to the eggs' ability to survive in the environment for long periods of time [19, 56]. *Trichuris suis* was most prevalent in piglets according to our findings which was in accordance with report in Nigeria [8] and is a known common cause of diarrhoea in young pigs [57].

Oesophagostomum spp. prevalence was 10% in the present study. Reports from China [38] Kenya [58] recorded a lower prevalence of 3.9% and 6.7% respectively. However, another study in Kenya [59] reported a higher prevalence of 27.0%. *Oesophagostomum* spp. eggs and early external larval stages are more sensitive to environmental conditions, however the infective third stage (L3) is more resilient and can survive in the environment for up to a year [23].

Based on epidemiological studies, *Moniezia* spp. are considered exclusive tapeworms of domestic ruminants, with pigs largely considered as accidental hosts of this parasite [35]. In Ghana, this parasite has been previously documented in ruminants, in goats, sheep and cattle [60]. The raising of pigs in proximity to ruminants coupled with rampant passage of *Moniezia*-infested faeces into the environment by ruminants scavenging for food creates ideal conditions for pigs to ingest *Moniezia* eggs. Consequently, these coprophagous animals can passively shed *Moniezia* eggs, as these eggs can pass through the digestive system intact owing to their robust nature.

The prevalence of *Toxocara* in the pigs sampled was 2%. Farmers in our study area usually keep pets such as cats and dogs at the farms for companionship and security purposes. Infected dogs and cats may shed *Toxocara* eggs in their faeces in pens of pigs since they have easy access to the pens [61]. Within 2 to 4 weeks *Toxocara* larvae develop inside the eggs and become infectious. The strong protective layer of Toxocara eggs allows them to persist in the environment for long, thus pigs can be infected by accidentally ingesting *Toxocara* eggs.

Hookworm was the least reported nematode, detected in only one percent (1%) of the faecal samples. Hookworms could be *Necator americanus* or *Ancylostoma* spp. since they are morphologically indistinguishable and therefore a need for molecular technique to identify them at the species level. Steenhard, et al. [62] reported that pigs in Northern Ghana were capable of excreting viable hookworm eggs after feeding on human faeces [62]. Adhikari, et al. [19] confirmed this association in Kintampo North in Ghana and demonstrated that pigs have a likely role in the transmission of *Necator americanus* in endemic communities [19]. It is important to that hookworms are zoonotic pathogen hence pigs could play the role of reservoirs in the spread of infections.

Polyparasitism was observed in pigs, with multiple infection (53.50%) being more common than single infection (35.25%). This agrees with a study conducted in Nepal [19] who reported higher multiple infection of 85%. Reports in Nigeria [8] recovered tripled infection in a pig whilst our study recorded a single pig having as high as septuplet infection with Adhikari, et al. [19] reporting same [19]. Multi-parasitism exploits the host immune system [63] and may have negative effects on pigs such as reduced weight, slow growth rate and helminthoses [64]. For example, multi-parasitic gastrointestinal infections, including *Cryptosporidium* spp. led to mortality of piglets in Australia [65]. The effects of mixed infections of parasites rather than a single species should be evaluated while determining the degree of infections and the resulting pathosis [52, 66].

Majority (43%) of the farmers were illiterate with respondent from Afigya Kwabre and Sekyere Districts being the highest. Ahafo Ano South District recorded the highest number of farmers with tertiary education (13%). There was a clear relationship between educational level of farmers and husbandry management practices. Farmers with high education followed a more scientific method of animal husbandry and were well informed about the rationale behind every practice. The majority of farmers who were illiterate and learnt the farming from experience were relatively less informed in pig science though being very skillful. These farmers ought to have depended more on the veterinarians in disease management than their highly educated colleagues but that was not the case. In this regard, there was higher prevalence of gastro-intestinal parasites in traditional farms where most farmers had little educational background to persons with higher education [67]. Afigya Kwabre and Sekyere Central District recorded higher GI parasites compared to Ahafo Ano South District since most farmers were highly educated in the latter than the former.

In relation to location, there was higher prevalence of gastro-intestinal parasites in Afigya Kwabre and Sekyere Central District compared with Ahafo Ano South District. Most pig farms in Ahafo Ano South District were industrial farms with ultra-modern facilities, and farmers practiced effective management practices such as timely deworming of pigs and regular cleaning of pens. However, most farms in Afigya Kwabre and Sekyere Central District were traditional or family farms where pigs were kept in unclean and unhygienic pens.

5. CONCLUSION

The finding shows approximately ninety percent (90%) of the study pigs were infected with gastrointestinal parasites, mostly nematodes. The top five parasites being *Eimeria* spp. (64.5%), *Ascaris* spp.(38.0%), *Strongyloides ransomi*(28.5%), *Oesophagostomum* (10.0%), and *Trichuris suis* (10.0%). Parasitism in pigs did not vary by sex, age, breeds and management systems. The lack of awareness on the transmission of zoonotic diseases from pigs to humans and lack of proper veterinary care for the pigs are of serious public health risk. It is recommended that well informed preventive and control measures should be put in place to combat gastrointestinal parasites in pigs and prevent their spread to other animals and humans as well. These measures should include prophylactic and therapeutic antihelminthic programs which would ultimately lead to increased productivity. The study needs to be replicated in other parts of the country to give a comprehensive idea of the geographical deviation of gastrointestinal infection among pigs across the country.

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