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Epidemiology of gastrointestinal worm infections in pigs reared in Enugu State, Nigeria

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Abstract Gastrointestinal worm infections (GWI) constrain pig production and zoonotic pig parasites make pork unsafe for human consumption. This study determined the distributions, determinants and dynamics of GWI and also the effect of the infection on production parameters in pigs reared in Enugu State, Nigeria. The GWI were determined by faecal egg counts following standard procedure. Sixty piggeries and 564 pigs were randomly selected for the study. Questionnaire survey was conducted to obtain data on some production parameters and risk practices aiding GWI in the piggeries. An overall prevalence of 88.3% (53/60) and 68.1% (384/564) at farm and individual pig levels respectively were recorded. High egg counts of single and mixed infections involving *Strongyle*, *Ascaris* and *Trichuris* species were found. The infection predominated in young (74.1%, 240/324) and female (72.3%, 272/376) pigs during the rainy/wet season (74.5%, 204/274). Rearing pigs of different ages together, feeding pigs with untreated abattoir/poultry waste, and unhygienic on-farm feed compounding were the major risk practices underpinning acquisition and spread of GWI. Infected piggeries had less litter weight and reduced mean weight at weaning and maturity. Pre-weaning piglet mortality was 15.5%. The seasonality and preponderance of the infection in young and female pigs are useful epidemiological findings which could be exploited for development of an effective control strategy against the parasitic infections. An overhaul of parasitic disease control measures in piggeries in Enugu State is imperative for greater productivity and profitability in swine production, and to boost availability of safe and wholesome pork for human consumption.

Keywords Epidemiology · Gastrointestinal worm · Helminthiasis · Nigeria · Pig production parameters · Risk practices

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Introduction

The domestic pig, *Sus scrofa domesticus,* is reared in most parts of the world for provision of pork, biomedical raw materials and manure. Pork constitutes about 44% of meat consumed globally (FAO 2015). Nigeria is the leading producer of pig in the West African Sub-region, responsible for about nine million pigs, which represent 64.3% of the 14 million pigs reared in the Sub-region (Ajibo et al. 2020). In Nigeria, pig production activities are concentrated in the southern and middle-belt regions, due to religious or cultural restrictions to pig farming and consumption of pork in most parts of the North (Nwanta et al. 2011; Ajibo et al. 2020).

Consequently, pig farming is the second largest agribusinesses in Enugu State, where pig rearing is undertaken as an alternative source of income or precautionary measure against crop failure (Njoga et al. 2018a, 2019). The polytocous nature, high feed conversion efficiency, early maturing nature, short gestation length and ability to thrive under sub-optimal tropical conditions confer pig comparative advantages over other food-producing animals. In addition, pig farming has the advantage of economy of space compared to ruminant productions. Moreover, the ease in the marketability of pork in most parts of the world seems to guarantee speedy returns on any investment in the swine industry (Nwanta et al. 2011).

Despite these comparative advantages, pig production in Enugu State, Nigeria is not thriving as expected, due to the endemicity and high burden of helminths that greatly limit productivity and profitability in swine production (Abonyi and Njoga 2020). Helminthiasis has continued to constrain pig production in Nigeria due to abundance and interconnectivity of epidemiological factors and farm practices enhancing survival and transmission of the parasites (Ajibo et al. 2020). Pigs are at risk of gastrointestinal worm infections (GWI) due to their gluttonous appetite and omnivorous feeding habit (Onunkwo et al. 2011) especially when farmers are ignorant of biosecurity practices or do not prioritize them. One major problem associated with GWI in the pig industry is that it limits pork production and hence contributes to diminution of animal protein, especially in developing countries where the demand lags behind the supply (Ekere et al. 2018; Njoga et al. 2018b).

In both humans and animals, the symptomatology or clinical manifestations of helminthiasis may be similar. Low GWI may present no clinical sign or symptom. However, heavy or even mild infections may give rise to malnutrition, diarrhoea, dysentery, abdominal pain, emesis, in-appetence, un-thriftiness, general malaise, tiredness, impaired cognitive development and growth retardation in children (Ojha et al. 2014; Mulambalah and Ruto 2016; Ajibo et al. 2020). Anaemia as a result of petechial hemorrhage and decreased intestinal iron absorption due to the attachment sites of the parasites can result following chronic hookworm infections (Cross 1996).

Helminthiasis in piggeries connotes economic losses, specifically as regards costs of anthelmintics and veterinary services. In addition, the sequelae of GWI such as poor weight gain, emaciation, infertility problems, reduced liter size and delay in maturity or attainment of market weight imply economic wastages (Roesel et al. 2017); since the pigs have to be reared and fed for a longer period (Abonyi and Njoga 2020). Furthermore, some pig parasites especially the *Ascaris* spp. damage visceral organs, and hence may cause substantial financial losses due to condemnation of the damaged organs, during meat inspection in abattoirs (Ajibo et al. 2020).

Apart from the financial losses, some pig worms are zoonotic. Irrespective of host preferences, *A. suum* and *A. lumbricoides* have been shown to spread from pigs to humans and vice versa (Peng and Criscione 2012). These parasites make pork unsafe for human consumption and deter the sale or consumption of such pork or the products. High infection with *Ascaris* spp. is characterized by anorexia, stunted growth, pot-belly syndrome, intestinal obstruction and impaired cognitive function in children (Mulambalah and Ruto 2016; Ajibo et al. 2020). Cases of ascariasis are common in the Sub-Saharan Africa due to the synergy of climatic factors, unhygienic practices and high fecundity of the parasite (Abonyi and Njoga 2020), capable of releasing over 200,000 eggs per matured female per day (Vlaminck et al. 2014).

Despite the importance of GWI, epidemiological data on the occurrence of the infection and the transmission dynamics are sparse in Enugu State; notwithstanding widespread pig farming activities in the area. These data are imperative for effective control strategies against the infections. Therefore, this study determined the epidemiology of GWI in pigs reared in Enugu State and their effects on the production parameters. The findings will help to limit spread of the infections, boost pig production and hence the availability of safe and wholesome pork for human consumption.

Materials and methods

Study location and study design

The demographics and geographical location of the study location, Enugu State, has already been described (Okoli et al. 2018). Enugu State is situated on latitude 6°51′ 24°N, longitude 7°23′ 45°E and elevation of 1810 ft. above sea level (Njoga et al. 2018a; Ajibo and Njoga 2020). The state has relative humidity of 14%, annual rainfall range of 1520 to 2030 mm and temperature range of 20 to 46 °C (Nwanta et al. 2011). Moreover, the study area experiences rainy/wet (winter) and dry/hot (summer) seasons each year.

The study adopted a cross-sectional study design involving questionnaire and coproparasitoscopic studies. A minimum samples size of 384 was calculated for the study, using the formula: $n = Z^2P(1 - P)/d^2$; where n = required sample size, Z = normal deviate (1·96) at 5% significance level, and P = estimated prevalence of GWI. The sample size calculation was based on 50% estimated prevalence as described by Pourhoseingholi et al. (2013), since there is no published report (to the best of our knowledge) on GWI in pigs in Enugu State, Nigeria. However, 564 faecal samples were examined for accuracy and buoyancy of data.

Sample collection

Three local government areas (LGAs) in Enugu State were purposively selected for the study based on history of high pig farming activities. Simple random sampling (toss of coin) was used to select 60 piggeries (from over 100 available farms) and 564 pigs surveyed in this study. Selection of the piggeries was predicated on the consent of the farm owners. Farms that had anthelmintic treatment within 30 days prior to the survey were excluded from the study. In each selected farm, faecal samples were collected per rectum from 10% of the stock. Special care was taken to accommodate both sexes and all age categories in the selection of the 10%.

For each pig sampled, the body condition score (BCS) as described by Chikwanha et al. (2007) was determined. The body condition scoring was done by one researcher (for uniformity) and was based on a 4-point scale as follow: bad (1–1.9), poor (2–2.9), moderate (3–3.9) and good ($\geq$ 4). Age was determined from farm records (if available) or estimated, and then categorized as young (2–7 months) or adults ($\geq$ 8 months). Other epidemiological data like sex and season of the year were also recorded. The study lasted for three months (November, February and June). November and February represents early and late dry/hot seasons (winter) while June corresponds to core rainy/wet season (summer).

Coproparasitoscopic examination

The faecal examination for presence of helminth eggs was done using tube floatation technique in saturated $NaCl_2$ solution (Abonyi and Njoga 2020). Worm eggs found were morphologically identified to species level as described by Soulsby (1982). Faecal egg counts were expressed as eggs per gram (EPG) of faeces using modified McMaster counting technique and the egg counts categorized as low (< 300 EPG), mild (300-499 EPG) or high ($\geq$ 500 EPG) infections.

Questionnaire survey

Closed-ended-questionnaire (for ease of data collation) was used to obtain information on pig production parameters, socio-demographics of the farmers and their involvement in farm risk practices aiding acquisition and dissemination of GWI in the selected piggeries. The questionnaire was subjected to face and content validations as described by Bolarinwa (2015). Thereafter, it was pretested on 20 respondents at Awka, Nigeria in order to detect and correct possible errors that may arise in the actual survey. Cronbach's alpha test was performed to determine the internal consistency/reliability of the data, using IBM® SPSS statistics version 23 (SPSS Inc., Chicago, Illinois, USA). This yielded reliability coefficient (alpha value) of 0.781 (which was $\geq$ 0.7) and indicated the reliability of the data/questionnaire.

Sixty copies of the pretested and validated questionnaire were used to obtain information on average litter size, average litter weight, mean weight at weaning, mean weight at maturity and pre-weaning piglet mortality. The information were obtained from farm record (where available) or from estimates provided by the farm workers.

Similarly, data bothering on farm management and biosecurity practice such as availability of deworming programme, regularity of dung removal, source and method of feed formulation were also obtained. The questionnaire was administered by local veterinarians and the content translated in the native language, to farmers who were limited in their ability to read and understand the English language. Thereafter, collation of the completed copies of the questionnaire for statistical analysis was done.

Data analysis and presentation

Data obtained in the study were analyzed and presented in tables and Fig. 1. Chi-square statistic or Fisher's exact test, as appriopriate, was performed to test for significant association ($p < 0.05$) between the worm infections and epidemiological variables (age, sex, season and sampling locations) and farm practices. Similarly, Student's t-test was also performed to compare the differences in means of various production parameters between farms with mild/high (EPG $\geq$ 300) and low/no (EPG < 300) infections. Casual association between the worm infections and the farm practices was accepted at $p < 0.05$ and or odds ration value greater than one. The analysis was done at 5% probability level using GraphPad Prism®, version 8.4.3 (GraphPad® Inc., San Diego, California, USA).

Results

Socio-demographics of the pig farmers

Majority of the farmers were males (78.3%, 47/60) and small-scale-farmers (68.3%, 41/60), having flock size of less than 100 pigs. On farming experience, 45% (27/60), 35% (21/60) and 20% (12/60) had less than 5, 6–10 and more than 10 years farming experiences respectively. Only 26.7% (16/60) of the respondents have had training on modern pig production methods. With respect to the highest educational level attained, 6.7% (4/60), 38.3% (23/60), 30% (18/60) and 25% (15/60) of the farmers had no formal education, primary (basic), secondary (post-primary) and tertiary educational levels respectively.

Prevalence of helminth species and body condition scores of pigs

Results on the species distribution of helminths found and the pattern of the infection are presented in Table 1. Helminth eggs belonging to *Strongyle, Ascaris, Trichuris* and *Metastrongylus* species were identified. The worm burden occurred as single (40.4%, 228/564) or mixed (27.7%, 156/564) infections. Prevalence of 16%, 11.7% and 9.6% was documented for single infections involving *Strongyle*, *Ascaris* and *Trichuris spp.* respectively. In cases of mixed infections, *Strongyle* and *Ascaris* spp. infections predominated and this accounted for 11% of the infections.

Ten *per cent* (57/564), 47.5% (268/564), 31.4% (177/564) and 11% (62/564) of the pigs had bad, poor, moderate and good BCS respectively. The parasitic infection was more in pigs having bad and poor BCS, with mean EPG values of 789 (high infection) and 417 (moderate infection) respectively (Table 2). Pigs in good BCS had the minimum GWI with mean EPG value of 266 (low infection). Statistical significance (p = 0.002) existed between BCS and the parasitic infection.

Prevalence of worm infections according to various epidemiological factors

The overall prevalence of GWI were 88.3% (53/60) and 68.1% (384/564) at farm and individual pig levels respectively. Detailed information on the age, sex and seasonal distribution of the infections are presented in Table 3. There was preponderance of GWI in young pigs (p = 0.0142, CI = 0.32–0.87), females (p = 0.042, CI = 0.33–0.95) and during the rainy season (p = 0.029, CI = 1.1–3). The odds of the infection were about two times higher in young and female pigs than in adult pigs and boars (Table 3). Significant statistical association existed between GWI and age, sex and season of the year (Table 3).

In addition, results on the spatial and temporal distributions of the parasitic infections were presented in Table 4 and Fig. 1 respectively. Of all the three LGAs surveyed, the worm infection predominated in Nsukka LGA with prevalence of 79% as against 61.3% in Udenu LGA. Similarly, there was preponderance of *Strongyle* spp. infection all through the period of the study while *Ascaris* spp. was frequently found during the rainy season (June) (Fig. 1).

Table 1 Species distribution of gastrointestinal worms found in pigs (n = 564) reared in Enugu State, Nigeria

Species of parasites	Number of pigs infected	Prevalence (%)
Single infections		
Strongyle spp.	90	16
Ascaris spp.	66	11.7
Trichuris spp.	54	9.6
Metastrongylus spp.	18	3.2
Mixed infections		
Strongyle spp. and *Ascaris* spp.	62	11
Strongyle spp. and *Trichuris spp.*	46	8.1
Strongyle spp. and *Metastrongylus* spp.	23	4.1
Ascaris spp. and *Trichuris* spp.	12	2.1
Ascaris spp. and *Metastrongylus* spp.	6	1.1
Strongyle spp., *Ascaris* spp. and *Trichuris* spp.	7	1.2

Risk factors for gastrointestinal worm infection in piggeries

Detailed results on the risk factors are presented in Table 5. All the 60 piggeries practiced intensive management system. The piggeries were involved in unhygienic on-farm feed compounding, including processing feed with bare hands, on bare floor and sometimes with unclean equipment. Other prominent risk factors found in some of the farms were feeding untreated abattoir waste or poultry droppings (OR = 6.9, CI = 1.19–36.9), un-availability of routine deworming programme (OR = 4.9, CI = 0.86–25.6), rearing pigs of different ages together (OR = 4.2, CI = 0.89–18.1) and non-removal of dungs on daily basis (OR = 2.4, CI = 0.43–12.8).

Effects of the worm infections on production parameters

Some of the 60 farms included in the study did not have records on some of the production parameters surveyed for but estimated values provided by the farmers sufficed. Infected piggeries had less litter weight, reduced mean weight at weaning and at maturity (Table 6). The overall mean pre-weaning piglet mortality was 16.5% and 14.5% in farms having high EPG value and those with little or no infection respectively. However, number of piglets per litter (litter size) was similar in both infected and uninfected farms (Table 6). Maternal overlay and diarrhea were the frequent causes of piglet mortality in the piggeries surveyed.

Table 2 Distribution of gastrointestinal worm infections in pigs (n = 564) surveyed in Enugu State, Nigeria according to body condition scores

Body condition scores (4-point scale)	Number of pigs sampled	Number of pigs infected	Mean EPG values	Prevalence (%)	P-value
Bad (1–1.9)	57	45	785	78.9	0.0017*
Poor (2–2.9)	268	190	417	70.9	
Moderate (3–3.9)	177	119	359	67.2	
Good (≥ 4	62	30	266	48.4	

* = Statistical significance, EPG = egg per gram of faeces, Chi-square test (GraphPad Prism® version 8.4.3)

Table 3 Age, sex and seasonal distribution of gastrointestinal worm infections in pigs (n = 564) reared in Enugu State, Nigeria

Epidemiological factors	Number sampled	Number infected	Prevalence (%)	Odds ratio	95% CI	P-value
Age						
Young (2–7 months)	324	240	74.1	1.9	0.32–0.87	0.0142*
Adult (≥ 8 months)	240	144	60			
Sex						
Female (sow)	376	272	72.3	1.8	0.33–0.95	0.0417*
Male (Boar)	188	112	59.6			
Season						
Wet (rainy) season	274	204	74.5	1.8	1.1–3.0	0.0299*
Dry (hot) season	290	180	62			

* = Statistical significance; CI = Confidence interval, Chi-square statistics (GraphPad Prism® version 8.4.3)

Discussion

The overall farm and individual pig levels prevalence of 88.3% (53/60) and 68.1% (384/564) respectively were significantly high considering that the pigs were intensively managed. This may be due to the bad and poor BCS (malnutrition) of the pigs which may have limited their ability to fight off the infections. The reverse is also true such that the parasitic infection may have resulted in the bad or poor BCS noted.

Pigs are naturally predisposed to GWI due to their voracious appetite and omnivorous feeding habit, especially when farm biosecurity practices are sub-optimal. Pigs feed on almost everything, including faeces, and are therefore at greater risk of GWI infection when compared to herbivours or ruminants that browse on fodder/forage. Consequently coprophagia, particularly feeding untreated dungs, may have enhanced the chances of the worm infections in the pigs. Furthermore, rooting is a natural habit in pigs, especially those raised on non-concrete bare floor. This feeding habit may also predispose to infection with soil-transmitted helminths. The interconnectivity of all these, couple with the fact that the phenomenon of "self-cure", which helps animals to spontaneously expel all worm infections as a result of exposure to a second larval infection, is not common in pigs (Abonyi and Njoga 2020). These may further explain the high prevalence of GIW found.

In addition, involvement of most farmers surveyed in farm practices capable of aiding GIW may have also contributed immensely to the high prevalence. Apart from feeding pigs with untreated abattoir wastes or poultry

Table 4 Spatial distribution of gastrointestinal worm infections in pig reared in Enugu State, Nigeria

Sampling locations	Number sampled	Number infected	Prevalence	P-value
Igbo-eze south	242	158	65.3	0.0014*
Udenu	160	98	61.3	
Nsukka	162	128	79.0	
Total	564	384	68.1	

* = Statistical significance, Chi-square statistics (GraphPad Prism® version 8.4.3)

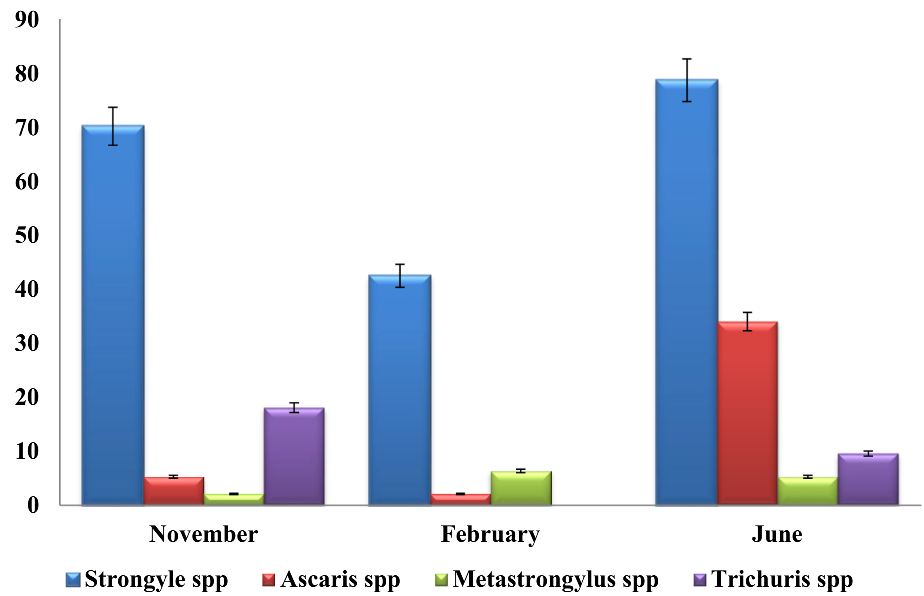

Fig. 1 Temporal distribution of gastrointestinal worm infections in pig reared in Enugu State, Nigeria

Table 5 Risk factors for gastrointestinal worm infections in piggeries (n = 60) in Enugu State, Nigeria

Risk/farm practices	Number of piggeries surveyed	Number of piggeries infected	Prevalence (%)	Odds ratio	95% CI	P-value
Feeding untreated abattoir waste or poultry droppings						
Yes	41	39	73.6	6.9	1.19–36.9	0.028*
No	19	14	26.4			
Rearing pigs of different ages together						
Yes	49	45	84.9	4.2	0.89–18.1	0.108
No	11	8	15.1			
Raising pigs on non-cemented bare floor						
Yes	31	28	52.8	1.5	0.37–6.34	0.702
No	29	25	47.2			
Un-availability of routine (every 3 months) deworming						
Yes	37	35	66	4.9	0.86–25.6	0.095
No	23	18	34			
Early weaning at less than six weeks of age						
Yes	29	25	47.2	0.7	0.16–2.71	0.702
No	31	28	52.8			
Non-removal of dungs on daily basis						
Yes	28	26	49.1	2.4	0.43–12.8	0.432
No	32	27	50.9			

* = Significant p-value, CI = Confidence Interval; Fisher's exact test (GraphPad Prism® version 8.4.3)

droppings, non-removal of dungs on daily basis as observed in this study may enhance the odds of GWI as feeding or drinking troughs may be contaminated with viable parasites from the faeces. This is particularly true considering the fact that most worm eggs are passed out through the faeces and transmitted via the feco-oral route.

Similarly, raising pigs of different ages together can exacerbate the chances of GWI from older carrier pigs to young ones. Early weaning, before the age of six weeks, usually compel young pigs to feed on formulated rations which carries greater risk of GWI than suckling on their dam (sow). In the event of the worm infection, these young

Table 6 Effect of gastrointestinal worm infection on production parameters of pigs (n-564) reared in Enugu State, Nigeria

Production parameters	Farms with mild or high worm infection (EPG $\geq$ 300)		Farms with low or no worm infection (EPG < 300)		P-value
	Range	Mean ± SEM	Range	Mean ± SEM	
Litter size (number of piglets per litter)	3–12	7.5 ± 2.6	4–12	8 ± 2.3	0.890
Litter weight (kg)	2–9	5.5 ± 2.0	3–15	9 ± 3.5	0.416
Weight at weaning (6 weeks) (kg)	6.2–12	9.1 ± 1.7	8.8–14.8	11.8 ± 1.7	0.305
Weight at maturity (8 months) (kg)	49–78	63.5 ± 8.5	60–88	74 ± 8.1	0.402
Pre-weaning piglet mortality (%)	5–28	16.5 ± 6.6	5–24	14.5 ± 5.5	0.824

Significance at $p \leq 0.05$, SEM = Standard error of the mean, Student' t-test (GraphPad Prism® version 8.4.3)

animals may be immunologically naive, due to their immature immune tissues, and therefore may not be able to fight off the infection. It seems therefore that the risk practices counteracted the benefit of low parasite infections inherent in intensive husbandry system; and predisposed pigs to worm infestations, hence the high prevalence found at the farm and individual pig levels.

The 68.1% prevalence being reported in this study is higher than 24.1% earlier reported by Wosu et al. (2015) for intensively managed pigs in the study area. This signifies 44% increase in GWI in just five years; and shows that the infection is speedily rising. The rise portrays defective control measures against the parasites. Development of anthelmintic resistance may be likely also, as most farmers have the habit of administering un-prescribed veterinary drugs to their animals in order to save cost of veterinary services (Njoga et al. 2018a).

Similarly, the 68.1% prevalence is higher than the findings of Sowemimo et al. (2012), Jatfa et al. (2019), Okoroafor et al. (2014) and Obisike et al. (2018) who reported prevalence of 35.8%, 53.7%, 32.7% and 50% respectively across different parts of Nigeria. On the global level, the prevalence is also higher than 25% documented by Jufare et al. (2015) in Ethiopia and 28% reported in Ghana by Atawalna et al. (2016). The differences in the findings could be due to disparity in factors capable of affecting the infection dynamics; such as climatic factors, nutrition, biosecurity and other management practices.

The preponderance of the worm infestation in female and young pigs may have immunological explanation. Young animals are immunologically naive and therefore highly susceptible to GWI. Stress and hormonal changes associated with gestation, farrowing and lactation in sows tend to lower their immunity and resistance to infections (Ajibo et al. 2020). Additionally, sows are kept in piggeries for a longer period than the boars. The extended period of rearing exposes sows to the infestation much more than the boars. Due to male dominance, female animals are sometimes compelled to feed on left over feeds which may be contaminated. These may have accounted for the higher worm burdens found in females than in males.

Higher prevalence of the infection during the rainy/wet season may be due to higher moisture content of the environment during this season (Kouam et al. 2018); and interplay of other climatic factors which may have enhanced the viability of the parasites and hence the transmission. The seasonality and preponderance of the infection in young and female pigs are useful epidemiological findings which could be exploited for development of an effective control strategy in the piggeries. This implies that female (especially the pregnant ones) and young pigs, should be specially cared for, and specifically targeted during routine deworming programmes particularly during the wet season.

The predominance of *Strongyle* and *Ascaris* spp. may be due to their ability to evade adverse conditions and high fecundity of *Ascaris spp.* (Abonyi and Njoga 2020). *Ascaris* eggs, depending on temperature, can persist in the tropical environment and remain infective for over six years (Asaolu and Ofoezie 2018). A matured female *Ascaris* sheds over 200,000 eggs per day (Vlaminck et al. 2014; Ajibo et al. 2020). Since humans are susceptible to both *A. suum* and *A. lumbricoides* (Peng and Criscione 2012); the 11.7% prevalence found for single infection with *Ascaris* raises doubt on the safety of pork produced, as the parasites are transmissible via the food chain.

Although the goal in worm control programmes in pig production is not zero prevalence, as this may be unattainable, wide spread occurrence of the infection especially with high EPG values as found in this work is inimical to swine production. High worm burden implies huge economic losses as the infection decreases growth rate by as much as 33% and leads to production of heavier plucks and less lean meat in pigs of all ages (Roesel et al. 2017). Porcine helminthiasis may also result in serious economic wastage due to organ damages (milk spot liver in pigs infected with *Ascaris* spp.) and the consequential condemnation during meat inspection. These are outside the financial losses that may accrue from costs of anthelmintics and provision of veterinary services.

Conclusion and recommendations

High EPG values of single and mixed worm infections involving *Strongyle*, *Ascaris* and *Trichuris* species occurred in pigs reared in Enugu State, Nigeria. Overall prevalence of 88% (piggery level) and 68.1% (individual pig level) which predominated in young and female pigs during the rainy season were significant. Rearing pigs of different ages together, feeding pigs with untreated abattoir/poultry waste, unavailability of routine deworming programme and unhygienic on-farm feed compounding were the major risk practices underpinning acquisition and spread of porcine helminthiasis in Enugu State, Nigeria. Infected piggeries had less litter weight and reduced mean weight at weaning and maturity.

Although anthelmintic therapy is important in modern pig production, good management practices (farm hygiene and strict biosecurity) could greatly limit GWI in piggeries. Good farm management practices include all-in-all-out flock replacement system and routine deworming programme involving prudent and rotational use of different anthelmintic classes. These may help to limit the worm infection and boost availability of safe and wholesome pork for human consumption.

Limitations of the study

The study's main limitation is the lack of proper record-keeping by the 60 piggery farms included in the study. The poor recording keeping warranted the use of estimated values provided by the farmers.

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Statement of animal rights All applicable international, national and/or institutional guideline for care and use of animals were followed.

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

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