Burdens of *Ascaris* spp. and *Cryptosporidium* spp. parasites in farm pigs in Ghana

John Asiedu Larbi1 | Seth Offei Addo1,2 | George Ofosu-Amoako1 | Uduakobong Christopher Offong1 | Efua Maclean Odurah1 | Samuel Kuranchie Akompong1

1 Department of Theoretical and Applied Biology, College of Science, KNUST, PMB, Kumasi, Ghana
2 Parasitology Department, Noguchi Memorial Institute for Medical Research, University of Ghana, Legon, Accra, Ghana

Correspondence
John Asiedu Larbi and Seth Offei Addo, Department of Theoretical and Applied Biology, College of Science, KNUST, PMB, Kumasi, Ghana. Email: larbijay@yahoo.co.uk; setthaddo40@gmail.com

John Asiedu Larbi and Seth Offei Addo contributed equally to this work.

Abstract

Background: Worldwide, intestinal parasites significantly affect the health and production of pigs.

Objective: This study assessed the prevalence of *Ascaris* and *Cryptosporidium* infection in pigs in the Ejisu-Juaben Municipality of Ghana.

Method: Faecal samples from two hundred (200) pigs on four different farms (labelled A, B, C, D) were processed using the Kinyoun modified Ziehl-Neelsen method for *Cryptosporidium* and the Formol-ether sedimentation method for *Ascaris* and microscopically examined to identify parasites to the genus level.

Results: The prevalence of *Ascaris* and *Cryptosporidium* in the pigs was 76% and 77%, respectively. The weaners had the highest *Ascaris* prevalence (96.15%) with the piglets recording the least (59.25%). On the other hand, the piglets had the highest prevalence (88.89%) for *Cryptosporidium* with the boars, sows and weaners recording 75.86%, 75.42% and 73.08% respectively. The prevalence of *Ascaris* was high in farm D (78.57%) while *Cryptosporidium* was highest in farm C (86.11%). Generally, there was a significant difference (*p* = 0.044) in the mean distribution of *Cryptosporidium* in the pigs.

Conclusion: The high burden of *Ascaris* and *Cryptosporidium* infections in the pigs suggest the need to adopt and implement effective control measures.

Keywords
*Ascaris*, *Cryptosporidium*, Ejisu-Juaben, pigs, prevalence

1 INTRODUCTION

Poor environmental hygiene leading to increased contamination of soil, water and food is reported as risk factors of parasitic infection in pigs (Levy et al., 2009). Infection of pigs with gastrointestinal parasites is also widely reported from all corners of the world and shown to be influenced by the type of pig management practised (Geresu et al., 2015). Some intestinal parasites, such as *Cryptosporidium* spp. and *Ascaris* spp., can be transmitted to other animals even including humans in many parts of the world especially in children and people with immunodeficiency diseases (Junhui et al., 2015). Although parasitic infections are usually subclinical, there are some cases of clinical infections occurring especially in growing pigs (Joachim et al., 2001; Weng et al., 2005). These parasites can restrict the growth of pigs,
affect sow productivity and increase the cost of production (Knecht et al., 2011; Pedersen et al., 2002; Symeonidou et al., 2020).

Gastrointestinal parasites greatly influence the productivity of pigs and other livestock industries by causing substantial economic loss (Boes et al., 2000). Generally, the parasites are transmitted via an oral-faecal route through infected food and water. The humid and warm conditions of the tropics as well as the deficient treatment of local pigs against parasitic diseases (Mashatise et al., 2005) invariably cause them to carry heavy burdens of gastrointestinal parasites. It is evident through various research findings of the widespread especially in Sub-Saharan Africa, gastrointestinal parasitic infections in pigs (Nwafor et al., 2019; Omoruyi & Agbinone, 2020; Youssao et al., 2018) with interbreeding humans and pigs has resulted in cross-species transmission (Anderson, 1995; Monteiro et al., 2019; Sadaow et al., 2018) with interbreeding humans and pigs has resulted in cross-species transmission (Anderson, 1995; Monteiro et al., 2019; Sadaow et al., 2018) .

The cross-sectional study was conducted in four intensive pig farms per farm) and accessibility for faecal sampling. An intensive management farming system was seen among all the farms visited. To date, about 37 Cryptosporidium species have been recognized (Čondlová et al., 2018; Kváč et al., 2018; Ryan et al., 2014; Zahedi et al., 2017), from which C. parvum, C. scrofarum, C. suis, C. tyzzeri, C. muris, and C. andersoni have been isolated from pigs (Kváč et al., 2013; Yu et al., 2014). Cryptosporidium parvum is a common intestinal parasite of humans and livestock (Guselle et al., 2003). Some studies have identified C. scrofarum and C. suis infections in immunocompromised patients suggesting their zoonotic potential (Bodager et al., 2015; Cam et al., 2007; Kváč et al., 2009; Leoni et al., 2006; Wang et al., 2013; Xiao et al., 2002). However, more studies are required to determine the zoonotic potential of these Cryptosporidium species.

In the case of Ascaris, human infections are known to be caused by Ascaris lumbricoides (Ali et al., 2020) while infections in pigs are caused by Ascaris suum (Zheng et al., 2020). However, the interaction between humans and pigs has resulted in cross-species transmission (Anderson, 1995; Monteiro et al., 2019; Sadaow et al., 2018) with interbreeding between Ascaris lumbricoides and Ascaris suum (Cricione et al., 2007; Peng & Cricione, 2012). More studies are required to establish the zoonotic transmission of Ascaris as it is unclear if pigs are significant reservoirs of human infection (Da Silva Alves et al., 2016; Leles et al., 2012).

The Ejisu-Juaben Municipality is among the largest pig-breeding sites in the Ashanti Region. It is a place where pigs are sold in large commercial numbers for people in Ejisu-Juaben Municipality and even extends to reach people outside the Municipality. However, there is little to no information on the prevalence of Ascaris and Cryptosporidium among pigs in the Region. Thus, this study aimed at determining the prevalence of these intestinal parasites and further suggests the need to create and implement control measures.

2 | METHODOLOGY

2.1 | Sample collection

The cross-sectional study was conducted in four intensive pig farms labelled as A, B, C and D in the Ejisu-Juaben Municipality. The pig farms were conveniently selected based on farm size (between 50 and 80 pigs per farm) and accessibility for faecal sampling. An intensive management farming system was seen among all the farms visited.

2.2 | Macroscopic and microscopic examination

Stool samples were examined by direct observation for mucus, blood, consistency (formed, soft or loose) and any adult parasites. Examination of stool samples for Ascaris was done using the Formal-ether concentration technique (Cheesbrough, 2006). To 2 g of a stool sample, 10 ml of formalin was added; mixture stirred using an applicator stick until a slightly cloudy suspension was attained and 4 ml of ethyl acetate added to the suspension and mixed properly for 1 min. The faecal suspension was sieved into a centrifuge tube and centrifuged for 1 min at 3000 rpm. The debris plug was loosened with an applicator stick and the supernatant decanted. One drop of the sample was placed on a clean microscope slide without any gross fibres and particles. Immediately, 1 drop of Lugol's iodine was then added and covered with a coverslip. The specimen was then examined with the low power objective lens (10x) beginning at one corner of the smear and systematically examined successive adjacent swaths with the high-power objective lens (40x) for the eggs of Ascaris.

The Kinyoun modified Ziehl-Neelsen method was used in the preparation of samples for identification of Cryptosporidium (El-Moamly & El-Sweify, 2012). Briefly, a few drops (one to two) of the specimen were then smeared on the slide and allowed to air dry. It was then fixed with absolute methanol for 1 min and dried at room temperature. Set up was flooded with Kinyoun’s carbol fuchsin for 5 min. The slide was rinsed briefly (3–5 s) with 50% ethanol and thoroughly with water thereafter. The smear was decolourized with 1% sulphuric acid for 2 min or until no more colour ran from the slide. The slide was rinsed with water, drained, counterstained with methylene blue for 1 min and rinsed with water. The slide was allowed to stand for air-drying. The prepared slide was finally mounted under the oil immersion objective for the morphological examination of Cryptosporidium oocyst.

2.3 | Statistical analysis

Results were organized using Microsoft Excel spreadsheet 2010 and analysed for significant differences between the mean distribution of egg/cyst per gram of stool (Ascaris and Cryptosporidium respectively) in pigs across the farms using ANOVA with SPSS IBMS 2.0v. The prevalence was calculated for all data sets as the number of infected
TABLE 1  Overall distribution of Cryptosporidium and Ascaris across the farm

| Farms | Number examined | Ascaris spp. | | Cryptosporidium spp. | |
|---|---|---|---|---|---|
| | | No. infected | Prevalence (%) | No. infected | Prevalence (%) |
| A | 109 | 84 | 77.06 | 80 | 73.39 |
| B | 41 | 31 | 75.61 | 31 | 75.61 |
| C | 36 | 26 | 72.22 | 31 | 86.11 |
| D | 14 | 11 | 78.57 | 12 | 85.71 |
| Total | 200 | 152 | 76.00 | 154 | 77.00 |

FIGURE 1  Prevalence of Cryptosporidium and Ascaris across pig groups in the farm

individuals divided by the total number of individuals examined, multiplied by 100. The level of significance was fixed at 95%.

3  | RESULTS

Out of the 200 pig samples examined, an overall prevalence of 77% of Cryptosporidium infection and 76% of Ascaris infection in pigs were recorded. (Table 1). A significant difference was observed in the mean distribution of Cryptosporidium in the pigs (p = 0.044). It was observed that boars and piglets were mostly infected with Cryptosporidium whereas sows and weaners were mostly infected with Ascaris (Figure 1).

3.1  | Prevalence of Cryptosporidium spp. and Ascaris spp. across various pigs in farms

The prevalence of Cryptosporidium spp. and Ascaris spp. were recorded categorically in boars, sows, weaners and piglets (Figures 2 and 3). Prevalence within the various farms showed no significant difference (p > 0.05).

3.2  | Mean distribution of cyst/eggs of Cryptosporidium spp. and Ascaris spp. in pigs across the farms

The mean distribution of Cryptosporidium spp. in the various pig groups saw the highest infection in the boars of farm D, sows of farm C, weaners of farm A and piglets of farm A (Table 2).

The mean distribution of Ascaris spp. in the various pig groups saw the highest infection in the boars of farm D, sows of farm A, weaners of farm B and piglets of farm C (Table 3).

4  | DISCUSSION

Gastrointestinal parasites cause significant problems in pig farming by affecting pig health, increasing morbidity in younger animals and extreme cases of death (Kagira et al., 2012; Pinilla et al., 2020). Studies suggest that Ascaris and Cryptosporidium infections in pigs could be of public health importance (Cavallero et al., 2013; Zhang et al., 2013); thus there is a need to establish the current prevalence in pigs and the potential risk to farmers.

In Ghana, C. hominis and C. parvum have been identified in children within the Ashanti Region (Eibach et al., 2015). Furthermore, Cryp-
**FIGURE 2** Prevalence of *Cryptosporidium* spp. across various pig groups in the farm

**FIGURE 3** Prevalence of *Ascaris* spp. across various pig groups in the farm

**TABLE 2** Mean distribution of *Cryptosporidium* spp. among pigs in various farm

|            | Farm A | Farm B | Farm C | Farm D |
|------------|--------|--------|--------|--------|
| Boars      | 3.44   | 4.33   | 2.2    | 6      |
| Sows       | 2.58   | 2.92   | 5.05   | 3.75   |
| Weaners    | 4.13   | 3.4    | 3.25   | 2      |
| Piglets    | 3.38   | 3.33   | 5.67   | 4.5    |

**TABLE 3** Mean distribution of *Ascaris* spp. among pigs in various farm

|            | Farm A | Farm B | Farm C | Farm D |
|------------|--------|--------|--------|--------|
| Boars      | 2.38   | 2.67   | 2.2    | 3      |
| Sows       | 3.8    | 3.08   | 2.19   | 1.63   |
| Weaners    | 3.53   | 5      | 4.25   | 3.5    |
| Piglets    | 2.31   | 1.67   | 3.5    | 1.5    |

tosporidium* spp. was found to be the cause of diarrhoea in children reporting to the Korle Bu Teaching Hospital in Accra (Adjei et al., 2004). Within the coastal savannah zone of Ghana, *Cryptosporidium* species were identified in farmers and livestock with *C. parvum* occurring in both humans and animals (Squire et al., 2017). It is important to note that *C parvum* is a zoonotic pathogen (Adegbola et al., 1994; Yu & Seo, 2004) hence livestock could play the role of reservoirs in the spread of infections.

In this study, even though there was no significant difference between the *Cryptosporidium* prevalence recorded from the various
farms (p > 0.05), it was observed that piglets were mostly infected with Cryptosporidium. It has been established that Cryptosporidium oocysts can survive for longer periods in the faecal matter as compared to bacterial pathogens (Hutchison et al., 2005). Thus, a lack of efficient hygienic practices on the farms could enhance the spread of this parasite. In addition, piglets being in close confinement with the sow, could facilitate the easy transmission of infection from the sow (Fablet, 2009). The use of water from a well and borehole on the farms could also influence the distribution of Cryptosporidium (Karalis et al., 2007). Originally isolated from pigs (Kváč et al., 2013; Yui et al., 2014), some studies have suggested the potential zoonotic transmission of C. scrofarum and C. suis to humans (Bodager et al., 2015; Wang et al., 2013; Xiao et al., 2002).

Although Ascaris lumbricoides infects humans (Ali et al., 2020) and Ascaris suum infects pigs (Zheng et al., 2020), there is evidence of cross-species transmission between humans and pigs within the same location (Anderson, 1995; Monteiro et al., 2019; Sadaow et al., 2018). Furthermore, Ascaris lumbricoides and Ascaris suum can interbreed, posing a serious threat to public health (Criscione et al., 2007; Peng & Criscione, 2012). Although it is unclear if pigs are key reservoirs of human illnesses globally (Da Silva Alves et al., 2016; Leles et al., 2012), the possibility of Ascaris zoonotic transmission cannot be ruled out.

In Ghana, Ascaris lumbricoides has been identified in children at the hospital (Mirisho et al., 2017), school children (Orish et al., 2019), inhabitants of an orphanage (Duedu et al., 2015) and pregnant women (Abaka-Yawson et al., 2020). Even though there is sparse information on Ascaris infection in livestock, studies have detected this parasite in goats, cattle and pigs (Atawalna et al., 2016; Futagbi et al., 2015; Mensah et al., 2018). In this study, the significant difference between the prevalence of Ascaris infection of the weaners and the boars, sows and piglets, and the sows and weaners could be due to the acquired immunity obtained by both the boars and sows over a consistent period of exposure to the source of infection.

It is important to note that the high prevalence of Ascaris infections in pigs is due to the large number of eggs produced and their ability to survive over a longer period (Hagel & Giusti, 2010). Poor environmental hygiene is said to also maintain or increase the intensity of Ascaris infection (Stothard et al., 2008). Additionally, Cryptosporidium oocysts have a protective wall that facilitates their survival in water and other environments (Thompson et al., 2008). This same protective coat makes the oocyst resistant to chlorination in water treatment (Bichai et al., 2008) and medical control of the oocysts in the pigs becomes difficult. Thus, to improve the health of pigs and increase production, it is necessary to adopt effective control measures against intestinal parasite infections and prevent or reduce transmission to farmers as well as exposure to the environment.

5 | CONCLUSION

The study revealed a high prevalence of Cryptosporidium and Ascaris among pigs in the various farms. These parasites affect animal health and could potentially be transmitted to humans; thus, there is a need of establishing control measures to reduce the burden of infections. Furthermore, it is suggested that molecular studies be carried out in the pig farms to determine the specific species of intestinal parasites causing infections.

ACKNOWLEDGEMENTS

The authors are grateful to the farmers for their support and cooperation to conduct this study. We are also grateful to the Department of Theoretical and Applied Biology (KNUST) for their support.

AUTHOR CONTRIBUTIONS

Seth Offei Addo: conceptualization, data curation, investigation, methodology, project administration, supervision, writing – original draft, writing – review & editing.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest.

ETHICAL STATEMENT

Voluntarily voided stools were used hence the animals were not directly handled. Verbal consent and permission was sought and obtained from farm owners prior to sample collection.

PEER REVIEW

The peer review history for this article is available at https://publons.com/publon/10.1002/vms3.756

DATA AVAILABILITY STATEMENT

All the data supporting the findings have been included in this article.

ORCID

Seth Offei Addo https://orcid.org/0000-0003-4470-4504

REFERENCES

Abaka-Yawson, A., Susu, S. Q., Kwadzokpui, P. K., Afari, S., Adusei, S., & Arko-Mensah, J. (2020). Prevalence and determinants of intestinal parasitic infections among pregnant women receiving antenatal care in Kasoa Polyclinic, Ghana. Journal of Environmental and Public Health, 2020, 1–7. https://doi.org/10.1155/2020/9315025

Adegbola, R., Demba, E., De Veer, G., & Todd, J. (1994). Cryptosporidium infection in Gambian children less than 5 years of age. The Journal of Tropical Medicine and Hygiene, 97(2), 103–107. https://europepmc.org/article/med/8169999

Adjei, A. A., Armah, H., Rodrigues, O., Renner, L., Borketey, P., Aye-Kumi, P., Adiku, T., Sifah, E., & Larney, M. (2004). Cryptosporidium spp., a frequent cause of diarrhea among children at the Korle-Bu Teaching Hospital, Accra, Ghana. Japanese Journal of Infectious Diseases, 57(5), 216–219.

Ali, S. A., Niaz, S., Aguilar-Marcelino, L., Ali, W., Ali, M., Khan, A., Amir, S., Nasreen, Alanazi, A. D., Cossio-Bayugar, R., & Amaro-Estrada, I. (2020). Prevalence of Ascaris lumbricoides in contaminated faecal samples of children residing in urban areas of Lahore, Pakistan. Scientific Reports, 10(1), 1–8. https://doi.org/10.1038/s41598-020-78743-y

Anderson, T. J. C. (1995). Ascaris infections in humans from North America: Molecular evidence for cross-infection. Parasitology, 110(2), 215–219. https://doi.org/10.1017/S0031182000063988
Atawalna, J., Folitte, R. D., & Amenakpor, C. (2016). Prevalence of gastrointestinal parasites among pigs in the Ejisu Municipality. Scholars Journal of Agriculture and Veterinary Sciences, 3(1), 33–36.

Bichai, F., Payment, P., & Barbeau, B. (2008). Prevention of waterborne pathogens by higher organisms in drinking water: A review. Canadian Journal of Microbiology, 54(7), 509–524. https://doi.org/10.1139/W08-039

Bodager, J. R., Parsons, M. B., Wright, P. C., Rasambainarivo, F., Roellig, D., Xiao, L., & Gillespie, T. R. (2015). Complex epidemiology and zoonotic potential for Cryptosporidium sp. in rural Madagascar. Veterinary Parasitology, 207(1–2), 140–143. https://doi.org/10.1016/j.vetpar.2014.11.013

Boes, J., Willingham, A., Fuhui, S., Xuguang, H., Eriksen, L., Nansen, P., & Stewart, T. (2000). Prevalence and distribution of pig helminths in the Dongting Lake Region (Hunan Province) of the People’s Republic of China. Journal of Helminthology, 74(1), 45–52. https://www.cambridge.org/core/journals/journal-of-helminthology/article/prevalence-and-distribution-of-pig-helminths-in-the-dongting-lake-region-hunan-province-of-the-peoples-republic-of-china/08BCEA2C12A191588609E5094B75B4BA

Cama, V. A., Ross, J. M., Crawford, S., Kawai, V., Chavez-Valdez, V., Vargas, D., Viver, A., Ticona, E., Navinocpa, M., Williamson, J., Ortega, Y., Gilman, R. H., Bern, C., & Xiao, L. (2007). Differences in clinical manifestations among Cryptosporidium species and subtypes in HIV-infected persons. Journal of Infectious Diseases, 196(5), 684–691. https://doi.org/10.1086/519842

Cavallero, S., Nabel, V., Pacella, F., Perrone, V., & D’Amelio, S. (2013). Phylogeographical studies of Ascaris spp. based on ribosomal and mitochondrial DNA sequences. PLoS Neglected Tropical Diseases, 7(4), e2170. https://doi.org/10.1371/journal.pntd.0002170

Cheesbrough, M. (2006). District laboratory practice in tropical countries. Cambridge, UK: Cambridge University Press.

Čondrović, Š., Horčičková, M., Sak, B., Květoňová, D., Hlásková, L., Konečný, R., Stanko, M., McEvoy, J., & Kváč, M. (2018). Cryptosporidium apodemi sp. n. and Cryptosporidium ditrichi sp. n. (Apicomplexa: Cryptosporidiidae) in Apodemus spp. European Journal of Protistology, 63, 1–12. https://doi.org/10.1016/j.ejop.2017.12.006

Criscione, C. D., Anderson, J. D., Sudimack, D., Peng, W., Jha, B., Williams-Futagbi, G., Abankwa, J. K., Agbale, P. S., & Aboagye, I. F. (2015). Assessment of helminth infections in goats slaughtered in an abattoir in a suburb of Accra, Ghana. West African Journal of Applied Ecology, 23(2), 35–42.

Geresu, M., Haillemariam, Z., Mamo, G., & Megersa, M. (2015). Prevalence and associated risk factors of major gastrointestinal parasites of pig slaughtered at Addis Ababa Abattoirs Enterprise, Ethiopia. Veterinary Science & Technology, 64(1). https://pdfs.semanticscholar.org/3315/011976a2efcaaaa3dabab0d533607ced8bd6a.pdf

Guselle, N. J., Appelbee, A. J., & Olston, M. E. (2003). Biology of Cryptosporidium parvum in pigs: From weaning to market. Veterinary Parasitology, 113(1), 7–18. https://doi.org/10.1016/S0304-4017(03)00039-6

Hagel, L., & Giusti, T. (2010). Ascaris lumbricoides: an overview of therapeutic targets. Infectious Disorders-Drug Targets (Formerly Current Drug Targets-Infectious Disorders), 10(5), 349–367. https://www.ingentaconnect.com/content/bentham/iddt/2010/00000100/00000005/art00005

Hutchison, M. L., Walters, L. D., Moore, T., Thomas, D. J. I., & Avery, S. M. (2005). Fate of Pathogens Present in Livestock Wastes Spread onto Festive Crops. Applied and Environmental Microbiology, 71(2), 691–696. https://doi.org/10.1128/AEM.71.2.691-696.2005

Joachim, A., Dünner, N., Daugschies, A., & Roepstorff, A. (2001). Occurrence of helminths in pig fattening units with different management systems in Northern Germany. Veterinary Parasitology, 96(2), 135–146. https://doi.org/10.1016/S0304-4017(00)00431-3

Jhunhi, D., Teng, Y. M., & Guangan, M. (2015). The prevalence of common intestinal parasites in domestic pigs in Shanya province of China. International Scholars Journals, 3(7), 104–108.

Kagira, J. M., Kanyari, P. N., Githigia, S. M., Maingi, N., Ng’ang’a, J. C., & Gachohi, J. M. (2012). Risk factors associated with occurrence of nematodes in free-range pigs in Busia District, Kenya. Tropical Animal Health and Production, 44(3), 657–664. https://doi.org/10.11120-0119-9511-9

Karanis, P., Kontenti, C., & Smith, H. (2007). Waterborne transmission of protozoan parasites: a worldwide review of outbreaks and lessons learnt. Journal of Water and Health, 5(1), 1–38. https://iwaponline.com/jwh/article-abstract/5/1/1987

Knecht, D., Popiolek, M., & Zaleśny, G. (2011). Does meatness of pigs depend on the level of gastro-intestinal parasites infection? Preventive Veterinary Medicine, 99(2–4), 234–239. https://doi.org/10.1016/j.prevetmed.2011.01.009

Kváč, M., Kestřanová, M., Pinková, M., Květoňová, D., Kalínová, J., Wagnerová, P., Kotková, M., Vítovc, J., Ditrich, O., McEvoy, J., Stenger, B., & Sak, B. (2013). Cryptosporidium scrofae n. sp. (Apicomplexa: Cryptosporidiidae) in domestic pigs (Sus scrofa). Veterinary Parasitology, 191(3–4), 218–227. https://doi.org/10.1016/j.vetpar.2012.09.005

Kváč, M., Květoňová, D., Sak, B., & Ditrich, O. (2009). A step closer to Extreme Drug Resistance (XDR) in Gram-negative bacilli. Emerging Infectious Diseases, 15(6), 982. https://doi.org/10.1007/s10538-012-2287

Kváč, M., Vínata, G., Ježková, J., Horčičková, M., Konečný, R., Hlásková, L., McEvoy, J., & Sak, B. (2018). Cryptosporidium occultus sp. n. (Apicomplexa: Cryptosporidiidae) in rats. European Journal of Protistology, 63, 96–104. https://doi.org/10.1016/j.ejop.2018.02.001

Leles, D., Gardner, S. L., Reinhard, K., Iğuez, A., & Araujo, A. (2012). Are Ascaris lumbricoides and Ascaris suum a single species? Parasites and Vectors, 5(1), 1–7. https://doi.org/10.1186/1756-3305-5-42

Leoni, F., Amar, C., Nichols, G., Pedraza-Díaz, S., & McLaughlin, J. (2006). Genetic analysis of Cryptosporidium from 2414 humans with diarrhoea in England between 1985 and 2000. Journal of Medical Microbiology, 55(6), 703–707. https://doi.org/10.1099/jmm.0.46251-0

Levy, K., Hubbard, A. E., Nelson, K. L., & Eisenberg, J. N. S. (2009). Drivers of Helminthology: Therapeutic targets. In Infectious Disorders-Drug Targets (Formerly Current Drug Targets-Infectious Disorders), 9(4), e2170. https://doi.org/10.1016/j.vetpar.2012.09.005

Levy, K., Hubbard, A. E., Nelson, K. L., & Eisenberg, J. N. S. (2009). Drivers of Helminthology: Therapeutic targets. In Infectious Disorders-Drug Targets (Formerly Current Drug Targets-Infectious Disorders), 9(4), e2170. https://doi.org/10.1016/j.vetpar.2012.09.005

Mashatise, E., Hamudikuwanda, H., Dzama, K., Chimonyo, M., & Kanengoni, A. (2005). Effects of corn cob-based diets on the levels of nutritionally related blood metabolites and onset of puberty in Mukota and Landracec Mukota gilts. Asian Australasian Journal of Animal Sciences, 18(10), 1469–1474. http://www.ajas.info/journal/view.php?number=21142
Menah, G., Bosompem, K., Ayeh-Kumi, P., Brown, C., & S. N. (2018). Parasitic load of cattle faecal matter from selected farms in Kpong and its health implications. Ghana Journal of Science, 58(0), 35–39.

Mirisko, R., Neizer, M. L., & Sarfo, B. (2017). Prevalence of intestinal helminths infestation in children attending Princess Marie Louise Children’s Hospital in Accra, Ghana. Journal of Parasitology Research, 2017, 1–7. https://doi.org/10.1155/2017/8524985

Monteiro, K. J. L., Calegar, D. A., Santos, J. P., Bacelar, P. A. A., Coronato-Mensah, G., Bosompem, K., Ayeh-Kumi, P., Brown, C., & S. N. (2018). Parasitic Larbi et al.

Ryan, U., Fayer, R., & Xiao, L. (2014). Cryptosporidium species in humans and animals: Current understanding and research needs. Parasitology, 141(13), 1667–1685. https://doi.org/10.1017/S0031182014001085

Sadaow, L., Sanpool, O., Phosuk, I., Rodpai, R., Thanchomnang, T., Wijit, A., Monteiro, K. J. L., Calegar, D. A., Santos, J. P., Bacelar, P. A. A., Coronato-Mensah, G., Bosompem, K., Ayeh-Kumi, P., Brown, C., & S. N. (2018). Parasitic Larbi et al.

Pinilla, J. C., Morales, E., Delgado, N. U., & Florez, A. A. (2020). Prevalence and risk factors of gastrointestinal parasites among swine bred in abstract: Parasites gastro-intestinaux chez les porcs élevés dans l’ État d’ Édo, au Nigéria: Abstrait: Introduction: Materials and method. African Journal of Clinical and Experimental Microbiology, 21(4), 349–353.

Orish. V. N., Ofori-Amoah, J., Ameganc-Aho, K. H., Osei-Yeboaah, J., Lokpo, S. Y., Osisigou, E. U., Agordor, P. D., & Adzaku, F. K. (2019). Prevalence of polysaccharide fermentation among primary school children in the Volta Region of Ghana. Open Forum Infectious Diseases, 6(4), 1–6. https://doi.org/10.1093/ofid/ofz125

Pedersen, S., Saeed, I., Michaelsen, K. F., Friis, H., & Murrell, K. D. (2002). Impact of protein energy malnutrition on Trichuris suis infection in pigs concomitantly infected with Ascaris suum. Parasitology, 124(5), 561–568. https://doi.org/10.1017/S0031182002001592

Peng, W., & Criscione, C. D. (2012). Ascarisiasis in people and pigs: New inferences from DNA analysis of worm populations. Infection, Genetics and Evolution, 12(2), 227–235. https://doi.org/10.1016/j.meegid.2012.01.012

Pinilla, J. C., Morales, E., Delgado, N. U., & Florez, A. A. (2020). Prevalence and risk factors of gastrointestinal parasites in backyard pigs reared in the bucaramanga metropolitan area, Colombia. Revista Brasileira de Parasitologia Veterinaria, 29(4), 1–10. https://doi.org/10.1590/S1984-29612020094

Ryan, U., Fayer, R., & Xiao, L. (2014). Cryptosporidium species in humans and animals: Current understanding and research needs. Parasitology, 141(13), 1667–1685. https://doi.org/10.1017/S0031182014001085

Sadaow, L., Sanpool, O., Phosuk, I., Rodpai, R., Thanchomnang, T., Wijit, A., Anamnart, W., Laymanivong, S., Aung, W. P. P., Janwan, P., Maleewong, W., & Intapan, P. M. (2018). Molecular identification of Ascaris lumbricoides and Ascaris suum recovered from humans and pigs in Thailand, Lao PDR, and Myanmar. Parasitology Research, 117(8), 2427–2436. https://doi.org/10.1007/s00436-018-5931-6

Squire, S. A., Yang, R., Robertson, I., Ayi, I., & Ryan, U. (2017). Molecular characterization of Cryptosporidium and Giardia in farmers and their ruminant livestock from the Coastal Savannah zone of Ghana. Infection, Genetics and Evolution, 55(December), 236–243. https://doi.org/10.1016/j.meegid.2017.09.025

Stothard, J., Imison, E., French, M., Sousa-Figueiredo, J., Khamis, I., & Rollinson, D. (2008). Soil-transmitted helminthiasis among mothers and their pre-school children on Unguja Island, Zanzibar with emphasis upon ascariasis. Parasitology, 135(12), 1447–1455. https://www.cambridge.org/core/journals/parasitology/article/soiltransmitted-helminthiasis-among-mothers-and-their-preschool-children-on-unguja-island-zanzibar-with-emphasis-upon-ascariasis/C3A85B2D3D5438C0771DCB6E59E4F72

Symeonidou, I., Tassis, P., Gelasakis, A. I., Tzika, E. D., & Papadopoulos, E. (2020). Prevalence and risk factors of intestinal parasite infections in Greek swine farrow-to-finish farms. Pathogens, 9(7), 1–14. https://doi.org/10.3390/pathogens9070556

Thompson, R., Palmer, C., & O’Handley, R. (2008). The public health and clinical significance of Giardia and Cryptosporidium in domestic animals. The Veterinary Journal, 177(1), 18–25. https://www.sciencedirect.com/science/article/pii/S1090023707003425

Wang, L., Zhang, H., Zhao, X., Zhang, L., Zhang, G., Guo, M., Liu, L., Feng, Y., & Xiao, L. (2013). Zoonotic Cryptosporidium species and Enterocytozoon bieneusi genotypes in HIV-positive patients on antiretroviral therapy. Journal of Clinical Microbiology, 51(2), 557–563. https://doi.org/10.1128/JCM.02758-12

Weng, Y. B., Hu, Y. J., Li, Y., Li, B. S., Lin, R. Q., Xie, D. H., Gasser, R. B., & Zhu, X. Q. (2005). Survey of intestinal parasites in pigs from intensive farms in Guangdong Province, People’s Republic of China. Veterinary Parasitology, 127(3–4), 333–336. https://doi.org/10.1016/j.vetpar.2004.09.030

Xiao, L., Bern, C., Arrowood, M., Sulaiman, I., Zhou, L., Kawai, V., Vivar, A., Lal, A., & Gilman, R. (2002). Identification of the Cryptosporidium pig genotype in a human patient. The Journal of Infectious Diseases, 185(12), 1846–1847. https://doi.org/10.1086/340841

Youssouf, S. Y., & Shibahara, T. (2014). Age-related detection and molecular characterization of Cryptosporidium suis in pigs pre- and post-weaned piglets and adult pigs in Japan. Parasitology Research, 113(1), 359–365. https://doi.org/10.1007/s00436-013-3662-2

Yu, J. R., & Sea, M. (2004). Infection status of pigs with Cryptosporidium parvum. The Korean Journal of Parasitology, 42(1), 45–47. https://doi.org/10.3347/kjp.2004.42.1.45

Yui, T., Nakajima, T., Yamamoto, N., Kon, M., Abe, N., Matsubayashi, M., & Shibahara, T. (2014). Age-related detection and molecular characterization of Cryptosporidium suis and Cryptosporidium scrofarum in pre- and post-weaned piglets and adult pigs in Japan. Parasitology Research, 113(1), 359–365. https://doi.org/10.1007/s00436-013-3662-2

Zahedi, A., Durmic, Z., Gofton, A. W., Kueh, S., Austen, J., Lawson, M., Callahan, L., Jardine, G., & Ryan, U. (2017). Cryptosporidium homai n. sp. (Apicomplexa: Cryptosporidiidae) from the guinea pig (Cavia porcellus). Veterinary Parasitology, 245(August), 92–101. https://doi.org/10.1016/j.vetpar.2017.08.014

Zhang, W., Yang, F., Liu, A., Wang, R., Zhang, L., Shen, Y., Cao, J., & Ling, H. (2013). Prevalence and genetic characteristics of Cryptosporidium spp. in pre-weaned and post-weaned piglets in Heilongjiang Province, China. PLoS ONE, 8(7). https://doi.org/10.1371/journal.pone.0067564

Zheng, Y., Xie, Y., Geldhof, P., Vlaminck, J., Ma, G., Gasser, R. B., & Wang, T. (2020). High anti-Ascariis seroprevalence in fattening pigs in Sichuan, China, calls for improved management strategies. Parasites and Vectors, 13(1), 1–5. https://doi.org/10.1186/s13701-020-3935-4

How to cite this article: Larbi, J. A., Addo, S. O., Ofose-Amoako, G., Offong, U. C., Odurah, E. M., & Akompong, S. K. (2022). Burden of Ascaris spp and Cryptosporidium spp. parasites in farm pigs in Ghana. Veterinary Medicine and Science, 8, 1119–1125. https://doi.org/10.1002/vms.3756