2022, Scienceline Publication
World's Veterinary Journal
World Vet J, 12(4): 388-394, December 25, 2022
ISSN 2322-4568

DOI: https://dx.doi.org/10.54203/scil.2022.wvj49

Seroprevalence and Associated Risk Factors of Porcine Cysticercosis in Boucle Du Mouhoun Region of Burkina Faso: A Cross-sectional Survey

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ORIGINAL ARTICLE
pii: S232245682200049-12
Received: 09 September 2022
Accepted: 26 October 2022

ABSTRACT

Taenia solium cysticercosis is a neglected tropical zoonosis with economic and public health importance. Cysticercosis is widely present in low-income countries with extensive pig breeding systems and poor human hygiene practices. In Burkina Faso, a study on porcine cysticercosis has been done only in Boulkiemde province. There is a lack of serological data on this disease in other areas, such as Balés province in the Boucle du Mouhoun region. This study aimed to assess the prevalence and risk factors of porcine cysticercosis in Boucle du Mouhoun, Burkina Faso. A total of 373 serum samples were collected from local breed pigs that were randomly selected from four villages in the mentioned region. Data were also collected using a structured questionnaire to determine explanatory factors for the infection. Serum samples were tested using an antigen ELISA test to detect circulating antigens of *Tænia solium*. The prevalence of the disease was 54.9% (95% CI = 49.8-59.9). Following univariate and multivariate logistic regression analysis, pigs originating from Kombia were found to be a protective factor (OR=0.54, 95% CI = 0.33-0.89). Male pigs were more likely to be infected than females (OR= 1.7, 95% CI = 1.09-2.64). The prevalence and factors associated with *Taenia solium* cysticercosis were identified and according to these data, porcine cysticercosis had a high prevalence in this area. Therefore, it is important to implement control actions focusing on disease control and public health for people infected with *Taenia solium*.

Keywords: Burkina Faso, Prevalence, Pigs, *Taenia solium*, Zoonosis

INTRODUCTION

Cysticercosis caused by *Taenia solium* (*T. solium*) has important public health and socioeconomic impact, mainly in developing countries (Murrell et al., 2005). Human is the definitive natural host and harbors the adult tapeworm and becomes infected by ingesting undercooked or raw pig meat with the parasite cysts. Pigs act as intermediate hosts. The transmission to pigs occurs when they ingest human feces or water/feed contaminated by *T. solium* eggs. Dogs can also act as intermediate hosts, and transmission to dogs occurs in the same conditions as pigs (Wandra et al., 2015; Ito et al., 2016). Humans, as accidental intermediate hosts, are infected when they accidentally ingest the parasite eggs with water or food or during auto-infestation (García et al., 2003; Murrell et al., 2005). As accidental intermediate host, the cysts might locate in the eyes and central nervous system, and this lead respectively to ocular cysticercosis and neurocysticercosis (Murrell et al., 2005). In animals, cysticercosis is commonly asymptomatic, but human infection can cause headaches and varying focal neurological manifestations, hydrocephalus, chronic meningitis, lacunar infarct syndromes, neuropsychiatric manifestations, and blindness (Murrell et al., 2005). Different prevention and control methods are described in the literature, including pig meat inspection, improved pigs husbandry practices, pigs vaccination, basic sanitary facilities, health education, etc. (Murrell et al., 2005). Regarding risk factors, extensive or free-range pig husbandry, open human defecation, consumption of human feces by pigs, deliberate use of human feces as pig feed, the connection of pig pens to human latrines, involvement of human carriers of the parasite in pig rearing and care has been described (Murrell et al., 2005).

In Burkina Faso, many studies have established the prevalence in humans between 0 and 37.5% (Carabin et al., 2009, 2015; Millogo et al., 2012; Nitiéma et al., 2012) in the Midwest region and Nayala province of Boucle du Mouhoun region. In pigs, the prevalence was estimated to range between 0 and 39.6% in the Midwest region, and

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infection was associated with the free-range keeping of pigs (Ganaba et al., 2011) as noticed in other studies in Africa (Sikasunge et al., 2007; Pondja et al., 2010; Ngwing et al., 2012; Assana et al., 2013). The national pig population was estimated to 2,345,803 and the Boucle du Mouhoun region pig population counted for 11.5% of the national pig population (INSD, 2016). Farming practices are mainly traditional with free roaming of pigs during the dry season but tethered or kept in small houses during the rainy season (FAO, 2012). According to these pig farming practices, pigs may be infested by ingesting human feces contaminated by *T. solium* eggs. Also, according to information collected from veterinary services in some villages of this region, pig meat is sometimes seized because of cysticercosis. However, no epidemiological study has been carried out to know the prevalence of porcine cysticercosis in this area and the factors associated with infestation. So, this study aimed to describe the prevalence and factors associated with *T. solium* cysticercosis in pigs from four villages in Boucle du Mouhoun region in Burkina Faso.

MATERIAL AND METHODS

Ethical approval

The study has been approved by the research board of Inter States School of Veterinary Sciences and Medicine (University of Dedougou, Burkina Faso) before its implementation. Informed consent was asked of each farmer included in the present study. Also, non-pregnant animals were dewormed using albendazole. All applicable international, national, and/or institutional guidelines for the use of animals were followed.

Study area

This cross-sectional study was implemented from December to April 2017 during the dry season. It took place in the province of the Balés, located in the Boucle du Mouhoun region in Burkina Faso. Four villages in Fara county were chosen for this study (Figure 1). The villages are set on regional road 11 between Poura Carrefour and the border with Ghana. Mainly animists are noted in Toné, Sadon Bobo, and Koumbia villages, where an important pig population was noted, except for Kabourou where there are many Muslims, with a small pig population. The area has a tropical climate with two seasons. The rainy season goes from May to September, with an average rainfall of 871 mm. Pigs are tethered or kept in little pens during the rainy season, while free roaming of pigs is noted in villages during the dry season. Human open defecation was noted in villages despite the presence of latrines in some households.

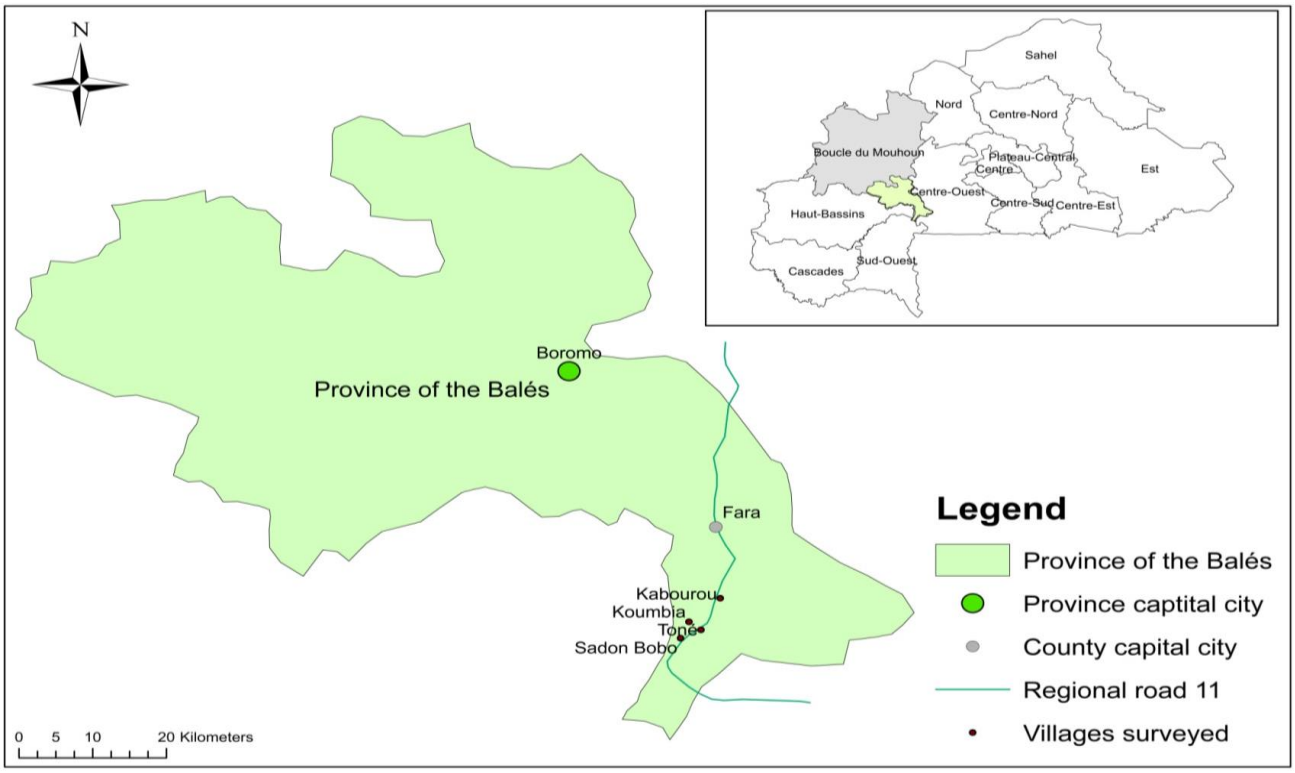

Figure 1. Location of the study area in the country

Sample size determination and samples collection

The sampling size was calculated using Win Episcope 2.0 software (Australia) with a precision of 5 %, a confidence level of 95 %, and expected prevalence of 32.5 % (Ganaba et al., 2011) and pig population of 270,504 (INSD, 2016). In the region, local and exotic pig breed was noted, but only local and mixed pig breed was considered for

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the sampling area. The minimum sample for this study was 338, but 376 blood samples were collected. Blood was collected using a 2ml blood collection tube (heparin) from the jugular vein. In each village, households were randomly selected by moving on roads in villages and selecting each pig-keeping household at intervals of 100 m. In each selected household, one pig was randomly chosen. From each animal sampled, blood was taken, and serum was harvested using centrifugation at 3000 RPM for 15 minutes. Because of the ELISA kit availability, only 373 serums were analyzed.

Questionnaire survey and direct observations

For each animal sampled, a survey was made in the household to identify factors that could be associated with pigs' infection. The presence of latrines, farmer gender, and the use of pig houses as latrines, pigs' sex, age, and breed were investigated. Also, information on pig access to human feces, anthelmintic use, and history of cysticercosis in the farm was noticed. All data were mentioned on a record sheet with the same ID as on the blood sampling tube.

Laboratory analysis

Laboratory analyses were made in the laboratory of Parasitology and Mycology of Inter State School of Veterinary Sciences and Medicine in Dakar (Senegal). The serums samples were tested for circulating antigens of the metacestode of *T. solium* detection with an Ag-ELISA (commercial Kit from ApDia, Belgium) test with the monoclonal antibody B158/B60 as described previously (Dorny et al., 2004). This test is used to detect viable cysticerci of *T. solium* based on manufacturer instructions. The test is known to have high specificity and sensitivity in pigs at 86.7% and 94.7%, respectively (Dorny et al., 2004).

Statistical analysis

After performing tests, investigations, observations, and serological tests, data were saved in a Microsoft (2007) Excel sheet. The overall apparent prevalence was calculated. Statistical software used was STATA 11 (StataCorp, USA). Respondents and pig characteristics were determined using descriptive statistics. First, a univariable logistic regression analysis was done to determine the association between each factor and *T. solium* infection. Factors with p-values ≤ 0.1 were included in a multivariable logistic stepwise regression analysis. For excluding factors one at a time, using $p > 0.05$ as the criterion, a backward elimination procedure was used. For all analyses, the significance level was set at 0.05. Only Farmer gender, the village of origin, and pig sex were included in the final model for multivariable logistic regression analysis. Prevalence and odds ratio are given with their confidence interval (CI).

RESULTS

Pig husbandry characterization

Among pigs' husbandries visited, 95.7 % of owners were women, and most (65.7%) sampled animals were sows (Table 1). The average age of sampled animals was 18.8 months. The local breed was most important (77.2%), and all pigs were roaming free during the dry season and enclosed in small houses (74%) or tethered at a pole or a tree (26%) during the rainy season. During the dry season, 25.5% of pigs' owners said that village people defecate in their piggery. Most of the household (87.7%) had latrines but only 15.5% had doors and 3% was clean. All pigs get access to human feces, and only 1.3 % were dewormed. More than two-thirds of pigs' owners (69.2%) noted that they had seen cysts on their pig slaughtered.

Serological data

Out of the 373 pigs' samples tested, 205 were positive, so the overall prevalence based on the detection of circulating antigens was 54.9% (95 % CI = 49.9 - 59.9%). The prevalence was higher at Koumbia (60.7% [95% CI = 50.7 - 70.7%]) than in other villages (Table 1). Prevalence was significantly higher at Toné, Koumbia, and Sadon Bobo than the one found at Kabourou ($p < 0.05$). Otherwise, the prevalence was significantly higher ($p < 0.05$) in boars (63.3%) than in sows (50.6%). Regarding farmer gender, the prevalence was significantly higher in pigs owned by men than those owned by women ($p < 0.05$) (Table 1). The prevalence was 52.9 %, 54.7% 55.1%, respectively, for pigs aged less than four months, between four and nine months, and for pigs aged more than nine months, but the variation was not significant ($p > 0.05$). Regarding the pig breed, the prevalence was 54.9 % and 55.3%, respectively, for a local and mixed breed, but no significant variation was noted ($p > 0.05$).

Risk factors associated to porcine cysticercosis

According to the multiple regression analysis, pigs which were males were 1.7 times more likely to have *T. solium* cysticercosis than females (Table 2 and Table 3). Likewise, only pigs from Koumbia were less likely to be infected with *T. solium* when compared with pigs from Kabourou (Table 2 and Table 3). Other variables included in the multivariable logistic regression were insignificantly different ($p > 0.05$).

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Table 1. Descriptive characteristics of farmers sampled local breed pigs with associated pig seroprevalences in four villages of Boucle Du Mouhoun region in Burkina Faso

Variables	Category	Number	Seroprevalence (95 % CI)	p value
Village	Kabourou	84	39.3 [29.3-49.3]	0.01
	Koumbia	79	60.7 [49.7-71.7]	
	Sadon Bobo	80	60 [49-70]	
	Toné	130	58.4 [49.9-66.9]	
Farmer experience	Less than 5 years	24	58.3 [38.5-78.0]	0.76
	Between 5 and 10 years	170	52.9 [45.4-60.4]	
	Above 10 years	179	56.4 [49.1-63.7]	
Defecation in pen	Yes	95	50.5 [40.4-60.5]	0.29
	No	278	56.5 [50.7-62.3]	
Farmer gender	Men	16	81.2 [62.1- 100]	0.04
	Women	357	53.8 [48.7-58.9]	
Pig sex	Boar	128	63.3 [55-71.6]	0.02
	Sow	245	50.6 [44.4-56.8]	
Pig breed	Local	288	54.9 [49.2-60.6]	0.94
	Mixed	85	55.3 [44.7-65.9]	
Age class	[0 - 4 months]	9	52.9 [29.9-75.9]	0.98
	[4 - 9 months]	60	54.7 [41.7-67.7]	
	> 9 months	304	55.1 [49.5-60.7]	
Presence of latrines in the households	Yes	327	56.3 [50.8-61.8]	0.29
	No	46	45.7 [31.3-60.1]	
Reared near latrine	Yes	327	56.3 [50.9-61.7]	0.17
	No	46	45.7 [31.3-60.1]	
Pigs' deworming	Yes	5	60 [17-100]	0.71
	No	368	54.9 [49.9-59.9]	
Former infestation of *T. solium* in the husbandry	Yes	258	56.6 [50.6 - 62.6]	0.34
	No	115	51.3 [2.2-60.4]	
Total animal sampled	-	373	54.9 [49.8-59.9]	

The significance level was set at 0.05

Table 2. Univariable logistic regression analysis of potential explanatory of *Taenia solium* cysticercosis in local breed pigs in Boucle du Mouhoun region in Burkina Faso

Variables	B-coefficient	p value at 95%CI
Farmer gender	1.32	0.04
Farmer experience	0.05	0.76
Village	0.78	0.01
Pig sex	0.52	0.02
Pig breed	0.02	0.94
Type of rearing	0.10	0.69
Reared near latrine	0.43	0.18
Defecate in pen	0.25	0.29
Deworm pigs	0.35	0.71

The significance level was set at 0.05

Table 3. Multivariable logistic regression analysis of selected potential predictors of *Taenia solium* cysticercosis in local breed pigs in Boucle du Mouhoun region in Burkina Faso

Variable	Category	B-coefficient	p value	Odds Ratio	95% Confident Interval for Odds Ratio
Village of origin	Toné	0.137	0.48	1.15	0.79-1.67
	Sadon Bobo	0.156	0.53	1.17	0.72-1.91
	Koumbia	-0.611	0.01	0.54	0.33-0.87
	Kabourou	Reference	-	1.00	-
Farmer gender	Male	1.136	0.08	3.11	0.87-11.17
	Female	Reference	-	1.00	-
Pig sex	Male	-0.53	0.02	1.70	1.09-2.64
	Female	Reference	-	1.00	-

The significance level was set at 0.05

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DISCUSSION

This study described the prevalence and the risk factors of *T. solium* cysticercosis in pigs in Boucle du Mouhoun region in Burkina Faso. The overall prevalence based on the detection of circulating antigens was 54.9%. This high prevalence could be linked to pig farming systems in villages. Also, most people practice open defecation in the area (Dahourou et al., 2018) and this situation allows pigs to get access to human feces infected by *T. solium* eggs (Sreedevi et al., 2012). This high prevalence could also be linked to the assay used as the Ag ELISA test does not allow differentiation between infection of different Taenia species (*T. solium, T. asiatica*, and *T. hydatigena*, Dorny et al., 2004). Even if *T. asiatica* is most located in Asia (Eom et al., 2009), *T. hydatigena* has been found to be prevalent in Burkina Faso (Dermauw et al., 2016). As dogs were found in the study area, some positive samples could be cross-reactions with *T. hydatigena*, so these data must be interpreted carefully. However, according to some observations that authors made in slaughter and tongue palpation during the field survey, most infections with *T. solium* were suspected according to cyst presence on the tongue and also cysts' location, and morphology on pigs' carcasses. The overall prevalence was higher compared to the prevalence found (0 to 39.6% according to the villages) by a previous study in the province of Boulkiemdé using the same Ag-ELISA assay (Ganaba et al., 2011). This difference could be associated with a higher number of carriers of *T. solium* and poor hygiene behaviors in the study area compared to their area. In this study, the prevalence was higher than the prevalence found by Kungu et al. (2017) in Uganda using the same technique and ELISA HP10 (12.2%), and also by Thomas et al. (2016) in Kenya, using the Ag-ELISA HP10 method, which was 37.6%. It was nevertheless lower than the prevalence found by Pondja et al. (2015) in the northwest of Mozambique (66.7%), in Benin (72.22%) by Goussanou et al. (2014), and South Africa (57%) by Krecek et al. (2012) with the same methods of the present study. The prevalence was significantly higher in boars compared to sows, as mentioned by Sikasunge et al. (2008) in Zambia.
For this study, some factors like farming system (free roaming or not) and access to human feces were not included in statistical analysis because all pigs were free roaming and had access to human feces while it has been described as risk factors in the country (Ganaba et al., 2011).

The prevalence was significantly lower in Kabourou than in the villages of Koumbia, Sadon Bobo, and Toné. The prevalence found was also significantly higher in pigs held by men. In the study area, pigs bred by men are not well feed; in this case, pigs spent much time looking for food and are therefore more exposed to infected human feces. There was no significant variation in infestation according to the pigs' age or their breed. Regardless of the breed or age of the animals, they are found wandering with the same risks of being in contact with infected human feces. According to Pondja et al. (2010) and Ngwing et al. (2012), the prevalence increases significantly with the age of the pigs in Mozambique and Cameroon, respectively.

Belonging to the village of Koumbia seems to be a protective factor. At this level, it is difficult to explain this situation, and further studies could clarify some. Also, being male was identified as a risk factor. Males might be more active in looking for a feed, so they are more exposed to ingesting human feces containing eggs of *T. solium*.

Findings noted that factors like rearing pigs near latrines, the existence of latrines in the household, human defecation in pen, and pig deworming were not significantly associated with infection. The use of latrines is an important factor to be assessed as, in some area, latrines could be present in a household, but people practice open defecation. This situation was previously described in Cameroon rural areas (Pouedet et al., 2002; Assana et al., 2010) and Mozambique (Pondja et al., 2010). In families with access to latrines, some people prefer open defecation, and in Zambia this is associated with taboos related to the use of latrines (Thys et al., 2015). Some farmers said that people used their pens as latrines, mainly during the rainy season. This situation seems to be very common in the study area, and maybe some wrong answers have been collected during field activities about this question. Pig deworming is not very frequent in the area; anthelmintic used are often out-of-date or not from official veterinary services. So, most of the time, farmers buy fraudulent drugs with no or low efficacy.

CONCLUSION

This study found a high prevalence of *T. solium* infection in pigs. Different factors were found to be associated with the infection. This is a serious public health problem for the people who consume pork and people living in the study area. It is important to design and implement control measures for this important zoonotic parasite in this area. Also, health education programs need to be implemented in this study area to reduce the risk of transmission of the disease to pigs and humans.

DECLARATIONS

Acknowledgments

Authors thank laboratory technicians and field technicians who assisted us during laboratory tests and field activities. Authors also thank local populations and local veterinary staff for their collaboration and help during field

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activities. Authors are grateful to Mr. Ouattara for his help during sample collection. Authors would also like to especially thank Sara Gabriel for her proofreading of the manuscript and language editing.

Authors' contribution

Laibané Dieudonné Dahourou, Oubri Bassa Gbati and Athanase Millogo designed the study. Laibané Dieudonné Dahourou, Kacou Martial NDA, Arnaud R. Stéphane TAPSOBA made field survey and laboratory analysis. Laibané Dieudonné Dahourou did statistical analysis validated by Amadou Traore. Laibané Dieudonné Dahourou proposed the draft of the manuscript. All authors made contributions to the revision of the manuscript. All authors read and approved the final manuscript.

Availability of data and material

The data from the present study are available on request from the corresponding author.

Competing interests

For this study, authors declare that there is no competing interest.

Funding information

This study was supported by the parasitology service of Inter States School of sciences and veterinary medicine, Dakar, Senegal.

Ethical considerations

Plagiarism, consent to publish, misconduct, data fabrication and or falsification, double publication and or submission, and redundancy have been checked by the authors.

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To cite this paper: Dahourou LD, Gbati OB, Nda KM, Tapsoba ASR, Traore A, Millogo A (2022). Seroprevalence and Associated Risk Factors of Porcine Cysticercosis in Boucle Du Mouhoun Region of Burkina Faso: A Cross-sectional Survey. *World Vet. J.*, 12 (4): 388-394. DOI: https://dx.doi.org/10.54203/scil.2022.wvj49

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