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Prevalence of Porcine Cysticercosis in Traditional Pig Farms (*Sus Scrofa Domesticus*) in the Department of Korhogo, Cote d'Ivoire

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Abstract **Original Research Article**

This study was conducted from May to September 2021 in northern Côte d'Ivoire. The objective was to determine the seroprevalence of porcine cysticercosis in traditional pig farms in the Korhogo department and to identify associated risk factors. A total of 360 serum samples collected from pigs in four (4) sub-prefectures of the department were analyzing using a specific indirect ELISA test for the detection of anti-*Cysticercus* antibodies in pig. Laboratory analyses revealed an overall porcine cysticercosis prevalence of 21.21% in the study area. Female pigs (23.25%) and animals aged 6 to 11 months (27.16%) appeared to have higher prevalence rates compared to males (19.14%), animals over 11 months (18.37%) and those aged 2 to 5 months (18.37%). The prevalence of porcine cysticercosis across the four investigated sub-prefectures ranged from 16.66% to 26.25%. However, statistical analysis indicated no significant association between infection prevalence and the risk factors studied (sex, age and rearing location). Furthermore, all investigated villages and farms recorded positive cases. The high prevalence of this disease in extensively farmed pigs underscores the necessity of establishing a surveillance system for this zoonosis, which can be fatal in humans.

Keywords: Pig cysticercosis, Seroprevalence, Risk factors, Korhogo.

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INTRODUCTION

Cysticercosis is a larval cestodiasis caused by cestodes of the *genus Taenia ssp*. It affects a wide range of hosts including domestic ruminants (cattle, sheep and goats), domestic carnivores (dogs, cats), lagomorphs (rabbits and hares), domestic swine and wild swine (wild boars, warthogs, etc.) and primates, including humans [1]. In humans, the disease has severe and potentially fatal consequences. It can cause epileptic seizures, debilitating headaches, intracranial hypertension, and ocular and/or muscular lesions [2]. Due to its significant impact on public health, cysticercosis has been identified as a leading cause of death from foodborne illnesses [3].

In swine, porcine cysticercosis is caused by *Cysticercus cellulosae*, the metacestode stage of *Taenia solium* [4]. Infection occurs following the ingestion of *Taenia solium* eggs from the environment, typically via contaminated human faeces or water [5]. In infected pigs, the disease manifests through the development of larval cysts in various muscles (e.g., tongue, diaphragm, heart, etc.), subcutaneous tissues (under the skin), the eyes and the central nervous system (brain and spinal cord). Consequently, it inflicts substantial enormous economic losses on livestock producers by rendering carcasses unfit for human consumption and leading to their seizure during veterinary meat inspection at slaughterhouses [6].

In Africa, an endemic region for porcine cysticercosis, prevalence rates ranging from 15% to 26.6% have been reported in Cameroon, the Congo, and Zambia, respectively [7, 8, 9, 10].

In Côte d'Ivoire, however, data on this condition in pigs are very limited. The first studies on this disease

were conducted at the Port-Bouet slaughterhouse in Abidjan in 1978 [11]. These early investigations reported a very high prevalence of porcine cysticercosis of 68.68% in pigs originating from the northen Cote d'Ivoire. In contrast, a subsequent study in 1991 found a national prevalence of only 3.6% [12].

More recent data from 2022 and 2023 revealed prevalence rates of 0.06% and 13.2%, respectively. The former was identified in pigs from modern, treated farms slaughtered at the Abidjan abattoir, while the latter was found in animals from farms in the southern part of the country [13; 14]. Despite these findings, there has been limited research on this disease in pig farms in northern Cote d'Ivoire, particularly in the Korhogo Department. This serological survey was therefore conducted to determine the seroprevalence of porcine cysticercosis in traditional pig farms within the Korhogo Department and to identify associated risk factors for infection, thereby contributing additional data to the epidemiology of this zoonosis.

MATERIALS AND METHODS

Study Area and Period

This study was conducted using blood serum samples collected in 2021 from traditional pig farms in the Korhogo Department. This area is an administrative division of Côte d'Ivoire and hosts the capital of both the Poro Region and the Savanes District (Figure 1). Covering an area of 12,500 km², the department had a population of over 440,926 inhabitants in 2021 [15].

The local economy is predominantly based on the primary sector, particularly agriculture (including cotton, cereals, yams). Livestock farming also constitutes a significant economic activity, as the department supports a substantital proportion of the national cattle and pig herd. A 2015 census identified 5,065 pig farms in the department, with a total herd size of 40,268 head [16].

Animal Sampling

For this preliminary investigation, a total of 360 blood samples were collected from pigs reared in traditional farming systems within the Korhogo Department.

Selection of Sub-Prefectures and Villages

This epidemiological survey was carried out in four sub-prefectures of the Korhogo Department. These administrative units randomly selected comprehensive list of sub-prefectures in the department. In these four sub-prefectures, twenty-two villages were chosen at random from the official village registers.

Farms and Animals Selections

In each village, a minimum of two farms, each maintaining at least ten animals over two months of age, were selected. The farms were identified using a networking system, which involved initially contacting a willing farmer with a herd meeting the size criterion. When this minimum could not be met, the number of farms surveyed was increased to allow for a maximum of 20 animals to be sampled per village. In such cases, the next farm was identified through a referral from the previously contacted farmer.

On the selected farms, only pigs older than two months were included in the study. Animals were chosen regardless of breed, sex or health status. On larger farms (those with more than 20 animals), individuals were chosen randomly, and the maximum sample size per farm was set at 16 animals.

Blood sampling and serum collection

From each subject, physically restrained in lateral recumbency, 5 mL of blood was collected via the external jugular vein into a plain vacuum tube. Each sample was immediately labeled with a unique identifier code specifying the sub-prefecture, village, farm of origin, as well as the animal's sex, age, and serial number.

The blood samples were transported to the laboratory and allowed to clot at room temperature (25°C) for 24 hours. Subsequently, they were centrifuged at 3000 rpm during 10 mn, and the resulting sera were aliquoted into 5 mL microtubes. These aliquots were labeled with their corresponding sample codes and stored at - 20°C until serological analysis.

Laboratory Analysis

The serological analysis was performed using a commercial Porcine Cysticercosis Antibody ELISA kit (Shenzhen Lvshiyuan Biotechnology Co., Ltd (Guangdong, PR China). The analyses were performed in accordance with the manufacturer's protocol. This test has a reported sensitivity of 96% and a specificity of 98%.

Data Processing and Statistical Analysis

Data were processed using Microsoft Excel to create databases, generate tables, and calculate prevalence rates. The seroprevalence (P) of cysticercosis was determined using the following formula:

$$Prevalence\ (\%) = \frac{\text{Number of seropositive samples}}{\text{Total number of samples analyzed}} \text{X}100$$

To investigate associations between the prevalence and potential risk factors, the data analyzed using the XLSTAT software, version 2019 (Addinsoft, Paris, France). Prevalence rates across different risk

factor categories were compared using Pearson's Chi-square test, with a statistical significance threshold set at $p < 0.05$.

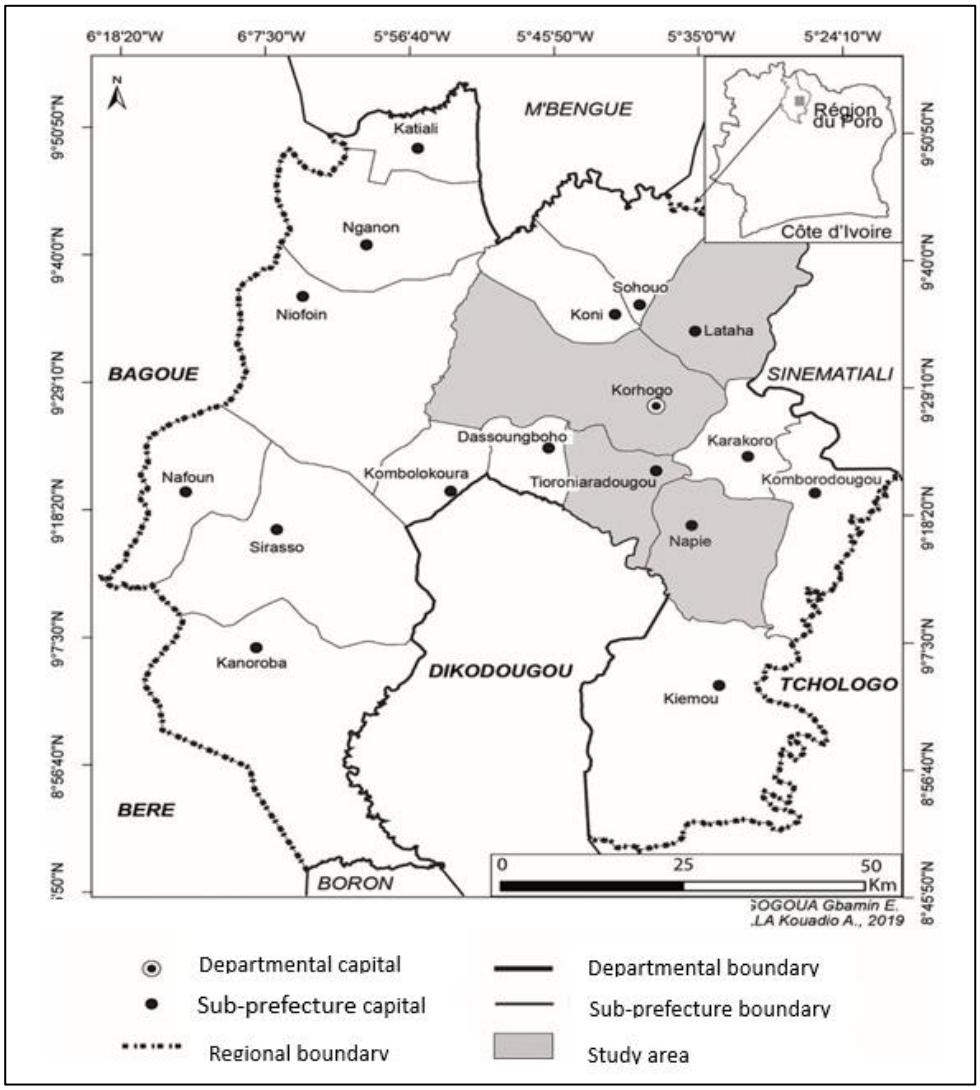

Figure 1: Study Area

RESULTS

Overall Distribution of Sampled Pigs

In the overall study population, the majority of sampled pigs were male (52.22%) and were six to eleven months of age (45%). At the sub-prefecture level, samples collected from Korhogo constituted nearly 50% of the total samples collected across the study area (Table I).

Table I: Distribution of sampled pigs by geographical origin, sex and age

LOCALITIES	SEX		AGE		
Sub-prefectures	Males Nber (%)	Females Nber (%)	2 - 5 months Nber (%)	6 - 11 months Nber (%)	> 11 months Nber (%)
Korhogo	88 (46,81%)	72 (41,86%)	44 (27,5%)	89 (55,63%)	27 (16,87%)
Lataha	36 (19,15%)	52 (30,23%)	27 (30,68%)	35 (39,77%)	26 (29,55%)
Tioro	26 (13,83%)	14 (8,14%)	14 (35%)	11 (27,5%)	15 (37,5%)
Napié	38 (20,21%)	34 (19,77%)	19 (26,39%)	27 (37,5%)	26 (36,11%)
Department of Korhogo	188 (52,22%)	172 (47,78%)	104 (28,88%)	162 (45%)	94 (26,12%)

Overall prevalence of cysticercosis

Of the 360 serum samples analyzed, 76 were positive for anti-*Cysticercus* antibodies, yielding an overall seroprevalence of 21.21%. This seropositivity rate varied according to the sex and age of the animals, as well as the sampling area (Table II).

Table III: Seroprevalence of porcine cysticercosis according to potential risk factors

Potential risk Factors		NPA/NAS	Prevalence (%)	Xhi²	P-value
Sex	Male	36/188	19,14%	-	-
	Female	40/172	23,25%	0,909	0,341
Age	> 11 months	18/94	18,37%	-	-
	6 - 11 months	44/162	27,17%	2,08	0,149
	2 - 5 months	14/104	13,46%	1,178	0,277
Sub-prefecture	Korhogo	42/160	26,25%	-	-
	Lataha	14/88	15,91%	3,473	0,062
	Tioro	8/40	20%	2,554	0,110
	Napié	12/72	16,67%	0,667	0,414

NPA: Number of Positive Animals NSA : Number of Sampled Animals

The prevalence of cysticercosis was higher in females (23.25%) than in males (19.14%). However, this observed difference in seropositivity was not statistically significant ($p > 0.05$). Therefore, no association was found between the sex of the animal and the prevalence of infection.

Regarding age, the seroprevalence of cysticercosis ranged from 13.46% to 27.17%. The highest rate (27.17%) was observed in subjects aged 6 to 11 months, compared to other age groups. However, the differences in prevalence across age categories were not statistically significant ($p>0.05$). Consequently, no association was found between the age of the animals and the

Seropositivity rate for cysticercosis.

Across the investigated sub-prefectures, the seroprevalence of cysticercosis varied from 15.91% to 26.25%. The highest seropositivity rate was recorded in the Korhogo sub-prefecture, while the lowest was in Lataha. Although geographical variations in prevalence were observed, these differences were not statistically significant ($p>0.05$). The prevalence of infection was not associated with the sampling area.

Positivity rate of sampled farms in each sub-prefecture

Of the 41 farms sampled, 27 contained seropositive animals, yielding a farm-level prevalence of 65.85%. The within-herd seropositivity rate varied from 0 to 75%. The highest recorded farm-level prevalence (75%) was in the Korhogo sub-prefecture (Table III). In this sub-prefecture, 76.47% of sampled farms had at least one positive case, compared to 45.45% of farms in Lataha.

Table III: Seropositivity rate of sampled farms in each sub-prefecture

Localities	NFS	NPF	Farm-Level Positivity Rate	Variation in Farm-Level Prevalence
Korhogo	17	13	76,47%	0% – 75 %
Lataha	11	5	45,45%	0% – 50 %
Tioro	5	3	60%	0% – 50 %
Napié	8	6	75%	0% – 25 %
Zone d'étude	41	27	65,85%	0% -75 %

NFS: Number of Farms Sampled NPF: Number of Positive Farms

Positivity rate in sampled villages per sub-prefecture

Analysis at the village level revealed that all sampled villages housed pigs seropositive for anti-*Cysticercus* antibodies, resulting in a village-level positivity rate of 100% (Table IV). Within these villages, the prevalence of porcine cysticercosis ranged from 6.66% to 44.44%. The highest prevalence of porcine cysticercosis (44.44%) was recorded in a village within the Korhogo sub-prefecture, whereas the lowest (6.66%) was found in a village in the Lataha sub-prefecture.

Table IV: Seropositive rates in sampled villages per sub-prefecture

Localities	Number of Sampled villages	Number of villages with positive cases	Proportion of villages with positive cases	Variation of prevalences in villages
Lataha	8	8	100%	6,66-31,25%
Korhogo	6	6	100%	14,28-44,44%
Napié	4	4	100%	15,78-17,64%
Tioro	4	4	100%	11,11-27,27%
Total	22	22	65,85%	6,66%-44,44%

DISCUSSION

This investigation into porcine cysticercosis involved the collection of 360 serum samples from pigs on traditional farms in the Korhogo Department, which were subsequently analyzed using an indirect ELISA specific for anti-*Cysticercus cellulosae* antibodies. Laboratory analysis identified 76 seropositive animals, corresponding to an overall seroprevalence of 21.12%. The high prevalence observed in the Korhogo Department may be attributable to traditional husbandry practices, where animals are often free-roaming and may have uncontrolled access to human faeces containing taeniid eggs or to contaminated pastures. Comparable prevalence rates, determined using the same serological technique, have been reported in other African countries, including Zambia (23.3%), Cameroon (21.78-26.6%), and Madagascar (15%) [7, 8, 9, 10]. However, our findings are higher than those reported in studies from Madagascar, the Congo, the Gambia, and Senegal, where lower prevalence rates of 5.20% (Mandritsara District, Madagascar), 2% (Congo), 0.2% (Gambia), and 0.1% (Senegal) [17, 4, 18]. This discrepancy can likely be explained by methodological differences. The aforementioned studies relied on techniques, such as tongue inspection and post-modern carcass examination, which are known to have low sensitivity, particularly in cases of light infection.

Regarding age, although a discernible variation was observed seroprevalence between adult pigs (18.37%) and younger animals (27.17% and 13.46%), statistical analysis confirmed no significant association between seropositivity and age ($p>0.05$). This finding could be attributed to the fact that post-weaning, which typically occurs around two months of age, piglets become highly exposed to contaminated environments. After weaning, young pigs roam independently and commonly engage in coprophagy and grazing on potentially contaminated pasture. Our results contrast with those from a study in Arivonimamo (Madagascar), which reported a higher prevalence in young pigs (39.75%) compared to older animals (20.5%) [19]. Conversely, other authors have reported divergent results, finding that adult pigs were at a significantly higher risk of cysticercosis than younger pigs [7, 20].

Furthermore, within the Korhogo Department, the prevalence of cysticercosis was higher in females (23.25%) than in males (19.14%). These findings align with those reported from the Mandritsara slaughterhouse in Madagascar [4], where a prevalence of 25% was recorded in females compared to 20% in males. However, our results contrast with studies conducted in 2018 in Arivonimamo (Madagascar) and in 2019 in the Congo [19, 20], where a higher seropositivity rate was observed in males. In those investigations, reported prevalences were 55.1% versus 44.91% in Arivonimamo and 1.25% versus 0.60% in the Congo for males and females, respectively.

The discrepancy between our results and these previous studies could be attributed to the longer lifespan of females in traditional farming systems. As females are typically retained as breeding stock, they are generally only culled upon exhibiting clinical illness or decining fertility. This extended lifespan provides a greater cumulative opportunity for exposure to *Taenia solium* eggs, making them significant reservoirs of infection due to prolonged, often subclinical, infestation.

Regarding geographical location, the analysis of our results indicates that the sub-prefectures most affected by porcine cysticercosis were Korhogo and Tioro, with prevalences of 26.25% and 20% respectively. This elevated prevalence may be attributed to the close cohabitation of livestock and human dwellings, coupled with a higher health risk of faecal contamination in these areas. Furthermore, all 22 sampled villages were found to harbor infected animals. These results confirm that porcine cysticercosis is a ubiquitous zoonosis and that the Korhogo Department is an endemic area for this disease. The similar observation was reported in Madagascar, where the parasitic disease was present in all investigated localities [21].

CONCLUSION

This sero-epidemiological study demonstrates that porcine cysticercosis is endemic within the Korhogo Department, with a high overall prevalence of 21.12%. Factors such as the sex and age of the animals were found not to be significantly associated with infection risk in this study.

The endemicity and high prevalence of this zoonosis pose a significant threat to public health, given its potential to cause severe neurocysticercosis in humans, and also result in substantial economic losses for the pig industry. Therefore, it is imperative to implement enhanced epidemiological surveillance and strengthen the veterinary inspection of pig carcasses destined for human consumption. Further research, particularly focusing on the genetic characterization of the circulating *Taenia solium* strains in the region, is warranted to better understand the local epidemiology of this neglected tropical disease.

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