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Risk Factors Associated with Prevalence of Porcine Cysticercosis in Slaughtered Pigs at Piggery Abattoir in Northern Senatorial Zone of Taraba State, Nigeria

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Abstract— Porcine cysticercosis is under-reported particularly in Nigeria, despite the reportedly high prevalence associated with life-threatening health implications. This study was aimed at determining the prevalence of porcine cysticercosis and risk factors related to the prevalence of infection in the study locations in the North Senatorial Zone in Taraba State. A questionnaire survey was carried out to collect information on the Socio-demographic characteristics of participants for anthropometric and cross-sectional studies employed on the prevalence of infection. A total of 350 pigs each were examined at four locations (Nukkai, Iware, Lamangoro, and Jalingo bye-pass) in both dry and rainy seasons and were analyzed by ANOVA. The results showed that 52.3% are not aware of cysticercosis. Preference of cooking, short cooking 90.3% vs 9.7 grilled meat. 36.9% vs. 63.1% were intensive and semi-intensive during rainy seasons. Infections across the study locations show that male pigs were most prevalent at 36.9% (120/350) and 9.7% (34/350) in female pigs. Binary logistic regression analysis indicated that in dry seasons 9.7 % (34/350) and 63.4% (222/359) in rainy seasons. There was a significant difference (P<0.05) in the prevalence of infection among male pigs in Nukkai and Iware whereas, infections in females across the study locations show a higher significance deference at (p<0.05). There was, however, a higher significant difference (P<0.05) in infection by intensive management whereas semi-intensive significance was observed in Nukkai (p<0.05%). Multivariable logistic regression analysis indicated that more prevalence of cysticerci of *T. solium,* was recorded in dry seasons 9.7 % (34/350) and 63.4% (222/350)) in rainy seasons. Risk factors associated with the prevalence of porcine cysticercosis in intensive and semi-intensive study communities were 57.1% (200/350) and 36.9% (129/350).

***Index Terms*— Seasons, Risk Factors, Porcine Cysticercosis, Taraba State, Nigeria.**

1. Introduction

Taenia solium, the source of porcine cysticercosis, is a rapidly spreading socioeconomic and public health issue on a globally [1], and domesticated pigs are the parasite's natural host and play a significant role in the transmission cycle [2] due to increased pig farming, pork consumption and their close proximity to people. Over 36% of all meat consumed worldwide is pork, making it one of the most popular meats [3].

The prevalence of porcine cysticercosis in Nigeria varies from 6.25% in the north to 20.5% in other parts of the country, where there are an estimated 6.54 million pigs with a semi-intensive management system in place [4]. Majority of these pigs are raised in the rural areas where they interact closely with people. Additionally, some of these pigs or their products are bought and transported to slaughterhouses or to be consumed in urban areas, a creating a situation that endangers potential purchasers from contracting the disease. According to epidemiological research, Porcine Cysticercosis (PC) is endemic in Latin American, Asia, and sub-Saharan Africa [2], [5], [6].

The parasite has a profound effect on the affected societies [5], and the larval worm, which frequently results in neurocysticercosis and epileptic convulsions in those afflicted, is thought to expose about 10 million people annually [7]. Since neurocysticercosis is the most frequent parasitic infection of the central nervous system causing epilepsy, more attention has been focused on this zoonosis in sub-Saharan Africa [8], which is a significant public health issue in developing nations, especially those in the Americas, Asia, and Africa [9].

Studies conducted in Nigeria and other developing nations have repeatedly shown that epilepsy is more common in rural than in urban regions [10]. Furthermore, eating pork infected with *T. solium* has been linked to an increased risk of developing epilepsy and is the primary cause of acquired epilepsy in endemic low-income countries. Moreover, a meta-analysis in Africa discovered a strong correlation between the incidence of epilepsy and cysticercosis infestation. Hence, this study was designed to address the lack of information regarding the knowledge and practices of pig workers and consumers regarding porcine cysticercosis and its risk factors in the Northern senatorial zone of Taraba State, Nigeria.

2. Methodology

A. Study Area

The study was conducted in Jalingo metropolis of Taraba

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state, which is the headquarters of the state. Located at 349 meters above sea level and situated at latitude 8.8929°N and longitude 11.3771°E, and the climate is typical of the tropics. During the rainy season, July through October sees a lot of rain, but May, June, and November see less. Annual mean temperature and rainfall is 27.9°C and 958 mm respectively. The highest mean temperature is experienced in April (32.2 °C) while the lowest in December (25.9 °C). January has the least amount of precipitation, averaging 0 mm, while August has the highest precipitation, averaging 217 mm.

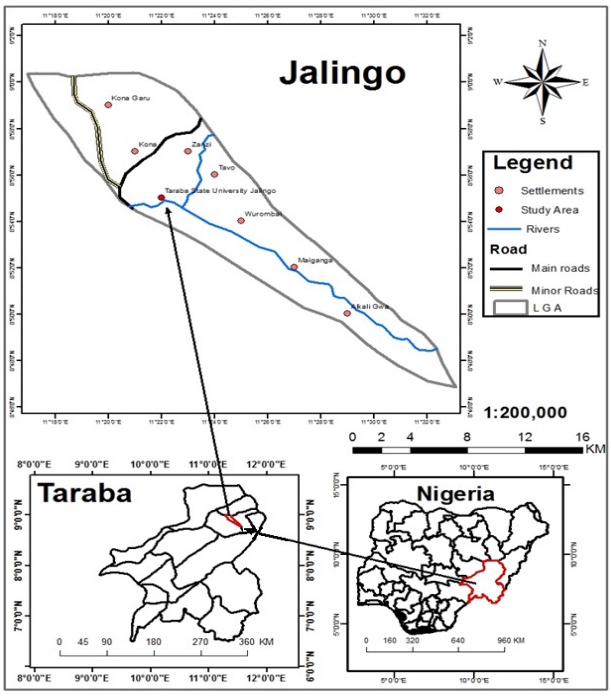

Fig. 1. Map of study area (Source: DIS analysis, 2017)

Study design, site, and sample size determination

The sample size of pigs that were sampled for the study was computed using the formula:

$$n = \frac{Z\alpha^2 pq}{L^2}$$

[11] where, n is the required sample size, Zα = 1.96 is the standard normal deviate at a 5% level of significance, p is the estimated prevalence, q = 1-p, and L is the precision of the estimate. Setting p=0.0625 [12] and L at 5%, the required minimum sample size was 90 pigs. However, we sampled a total of 700 pigs in dry and rainy considering seasons the volume of pigs slaughtered per day and to minimize the possibility of chances. In the same vein, from an average of 350 slaughterhouse workers who met the inclusion criteria of either working directly with pigs in the abattoir, having pigs at home, or eating pork, a total of 400 respondents were willing to participate in the study. Those who had neither handled pigs nor eaten pork were excluded from the study.

3. Results and Discussion

A. Socio-demographic Characteristics of Participants Used for Anthropometric Studies

Out of 350 slaughterhouse workers, the results showed that 122 (34.9%) and 32 (9.1%) had greater than 2 years and 10 years of pig rearing experience, and 52.3% are not aware of cysticercosis (Table 1). Preference of cooking, short cooking 90.3% vs 9.7 grilled meat. 36.9% vs. 63.1% were intensive and semi-intensive during dry and rainy seasons (Table 1). Infections across the study locations show that male pigs were most prevalent at 36.9% (120/350) and 9.7% (34/350) in female pigs.

The findings from this study on the socio-demographic characteristics of participants used for anthropometric studies and the prevalence of porcine cysticercosis among pigs slaughtered in different study locations reveal several approximately 34.9% of the slaughterhouse workers had more than 2 years of pig rearing experience, while 9.1% had over 10 years of experience. This suggests that a significant proportion of workers had substantial knowledge of pig-rearing practices

Table 1
Socio-demographic characteristics of participants used for anthropometric studies

Variable	Category	Frequency	Percentage
Year of pig-rearing experience	>2years	122	34.9
	>5years	117	33.4
	>10years	79	22.6
	> 10 years and above	32	9.1
	Total	**350**	**100.0**
Awareness of Cysticercosis	No	183	52.3
	Yes	167	47.7
	Total	**350**	**100.0**
Preference for cooking of pork meat	Short cooking	316	90.3
	Grilled meat	34	9.7
	Total	**350**	**100.0**
Methods of rearing pigs			
Intensive during dry seasons	No	129	36.9
	Yes	221	63.1
	Total	**350**	**100.0**
Semi-intensive during rainy seasons	Yes	128	36.6
	No	222	63.4
	Total	**350**	**100.0**
Pigs pen availability	No	182	52.0
	Yes	129	36.9
	Sometimes	39	11.1
	Total	**350**	**100.0**

in the study area. Alarmingly, more than half (52.3%) of the slaughterhouse workers were not aware of cysticercosis. This lack of awareness could contribute to the spread of the disease and highlights the need for educational interventions [13], [14].

The majority of participants (90.3%) preferred short cooking methods over grilling for meat preparation. This preference for shorter cooking times may not effectively kill the cysticerci, which can survive in undercooked pork, posing a risk to consumers. The preference for short cooking methods found in this study has implications for transmission risk, as inadequately cooked pork can contain viable cysticerci. This finding is consistent with studies emphasizing the importance of thorough cooking to kill the parasite [15].

The study observed differences in pig management practices between dry and rainy seasons. During the dry season, more intensive pig management was reported, possibly due to a higher demand for pork during festive periods. Seasonal variations in pig-rearing practices and their impact on cysticercosis prevalence have been observed in other studies as well. Factors such as temperature, humidity, and feed availability can influence pig management practices and subsequently affect the prevalence of cysticercosis [16].

B. Prevalence of Cysticercosis during the Study and Risk Factors

Animal sampling and prevalence of porcine cysticercosis among male slaughtered pigs in the study locations show that 49.2% (30/61) pigs in Nukkai had the highest prevalence of cysticerci of *T. solium,* Followed by 38.9% (44/113) in Lamangoro and 36.1% (26/72) in Jalingo bye pass. The least cysticerci of *T. solium* 27.9% (29/104) was recorded in Nukkai, in this category with varying parasite prevalence in male pigs in the study locations (Table 2). Across the study locations, there was a statistically significant difference in Iware ($p<0.05$) (Table 2).

The prevalence of porcine cysticercosis among female pigs slaughtered in the study locations shows that 12.5% (9/72) pigs in Jalingo bye passed the highest prevalence of cysticerci of *T. solium,* followed by 12.4% (14/113) in Lamangoro and 8.7% (9/104) in Nukkai. The least cysticerci of *T. solium* 3.3% (2/61) was recorded in Iware, in this category with varying parasite prevalence in females' pigs in the study locations (Table 2). Across the study locations, there was a highly statistically significant difference ($p<0.05$), (Table 2).

Multivariable logistic regression analysis indicated that more prevalence of cysticerci of *T. solium,* was recorded in dry seasons 12.5 % (9/72) and 12.4% (14/113) (OR: 0.748; CI: 0.869-2.229) in dry seasons in Jalingo bye pass and Lamangoro and 8.7% (9/104 vs 2/61) (OR: 0.692; CI: 0.768-2.789), (OR: 0.157; CI: 0.201-1.177) in Nukkai and Iware in study locations (Table 3). There was no significant difference ($P>0.05$) in the prevalence of infection in dry seasons in pigs across the study locations. In the rainy seasons, a higher prevalence of cysticerci of *T. solium,* was recorded in Nukkai with 72.1% (75/104), (OR: 0.121; CI: 0.129-1.000); 63.9% (46/72) ref.; 61.1% (69/113), (OR: 0.496; CI: 0.875-1.349). The least prevalence was recorded in Iware 52.5% (32/61). There was a highly significant difference ($P>0.05$) in the prevalence of infection in rainy seasons in pigs across the study locations (Table 3).

Multivariable logistic regression analysis indicated that more prevalence of cysticerci of *T. solium* was recorded in semi-intensive 65.5 % (40/61) in Iware (OR: 0.372; CI: 0.226-1.201), 63.7% (72/113) (OR: -0.098; CI: 0.491-1.670) in semi-intentive management in Lamangoro, 54.2% (39/72) ref. in Jalingo bye pass. The least porcine cysticercosis 47.1% (49/61), (OR: -0.364; CI: 0.754-2.745) was recorded in Nukkai in study locations (Table 4). There was a significant difference ($P>0.05$) in the prevalence of infection in Nukkai in pigs across the study locations (Table 4).

In the intensive management, a higher prevalence of cysticerci of *T. solium,* was recorded in Iware with 49.2% (30/61), (OR: 2.017; CI: 2.569-21.983); 38.9% (44/113) (OR:

Table 2
Prevalence of *Porcine Cysticercosis* among pigs gender slaughtered in the study locations

Communities	Gender	Total	N-v	P-v	X2	P-value
Nukkai	Male	104 (100.0)	75 (72.1)	29 (27.9)	0.589	0.446
Iwara	Male	61 (100.0)	31 (50.8)	30 (49.2)	7.452	0.006
Lamangoro	Male	113 (100.0)	69 (61.1)	44 (38.9)	0.712	0.399
Jalingo bye pass	Male	72 (100.0)	46 (63.9)	26 (36.1)	0.172	0.678
	Total	350 (100.0)	221 (63.1)	129 (36.9)		
Nukkai	Female	104 (100.0)	59 (91.3)	9 (8.7)	104.000	0.000
Iwara	Female	61 (100.0)	59 (96.7)	2 (3.3)	61.000	0.000
Lamangoro	Female	113 (100.0)	99 {87.6}	14 (12.4)	113.000	0.000
Jalingo bye pass	Female	72 (100.0)	63 (87.5)	9 (12.5)	72.000	0.000
	Total	350 (100.0)	316 (90.3)	34 (9.7)		

Table 3
Seasonal and risk factors associated with prevalence of *Porcine Cysticercosis* in the study communities

Communities	Seasons	Total	N-v	P-v	OR	CI	CI	X2	P-value
Nukkai	Dry	104 (100.0)	95 (91.3)	9 (8.7)	0.692	0.768	2.789	.157	0.692
Iwara		61 (100.0)	59 (91.3)	2 (8.7)	0.157	0.201	1.177	2.001	0.157
Lamangoro		113 (100.0)	99 (87.6)	14 (12.4)	0.748	0.869	2.299	0.103	0.748
Jalingo bye pass		72 (100.0)	63 (87.5)	9 (12.5)	Ref	Ref.	Ref.	0.310	0.578
	Total	350 (100.0)	316 (90.3)	34 (9.7)					
Nukkai	Raining	104 (100.0)	29 (27.9)	75 (72.1)	0.121	0.129	1.000	104.000	0.000
Iwara		61 (100.0)	29 (47.5)	32 (52.5)	29.586	1.789	2.988	57.124	0.000
Lamangoro		113 (100.0)	44 (38.9)	69 (61.1)	0.496	0.875	1.349	113.000	0.000
Jalingo bye pass		72 (100.0)	26 (36.1)	46 (63.9)	Ref	Ref.	Ref.	72.000	0.000
	Total	350 (100.0)	128 (36.6)	222 (63.4)					

Table 4
Risk factors associated with prevalence of *Porcine Cysticercosis* in intensive and semi-intensive in the study communities

Communities	Category	Total	N-v	P-v	OR	CI	CI	X2	P-value
Nukkai	Semi-Intensive Pigs	104 (100.0)	55 (52.9)	49 (47.1)	0.364	0.754	2.745	5.465	0.019
Iwara		61 (100.0)	21 (34.4)	40 (65.5)	0.372	0.226	1.201	0.131	0.717
Lamangoro		113 (100.0)	41 (36.3)	72 (63.7)	-0.098	0.491	1.675	0.000	0.989
Jalingo bye pass		72 (100.0)	33 (45.8)	39 (54.2)	Ref	Ref.	Ref.	0.002	0.967
	Total	**350 (100.0)**	**150 (42.9)**	**200 (57.1)**					
Nukkai	Intensive Pigs	104 (100.0)	75 (72.1)	29 (27.9)	-0.143	0.079	0.866	69.844	0.000
Iwara		61 (100.0)	31 (50.8)	30 (49.2)	2.017	2.569	21.983	12.359	0.000
Lamangoro		113 (100.0)	69 (61.1)	44 (38.9)	0.138	0.077	0.807	70.894	0.000
Jalingo bye pass		72 (100.0)	46 (63.9)	26 (36.1)	Ref	Ref.	Ref.	41.207	0.000
	Total	**350 (100.0)**	**221 (63.1)**	**129 (36.9)**					

0.138; CI: 0.077-0.807) 36.1% (26/72), ref. The least prevalence was recorded in Nukkai 27.9% (29/104) (OR: -0.104; CI: 0.079-0.866). There was however, a higher significant difference (P<0.05) in infection by intensive management whereas semi-intensive significance was observed in Nukkai (p<0.05%) in pigs across the study locations (Table 4).

Plate 1: slaughtered pigs on the slab

Plate 2: Pork meat

Plate 3: Presenting viable cysticercosis

Plate 4: Classified and death cysts

Variation in cysticercosis prevalence across different locations is a common finding in the literature. Local factors such as sanitation, pig management, and cultural practices can contribute to these differences. This study's findings add to the body of evidence highlighting the importance of location-specific interventions [17].

Male pigs exhibited a higher prevalence of cysticercosis compared to female pigs in the study locations. This finding suggests potential sex-related differences in susceptibility or exposure to infection. These findings agreed with [18] in Taraba State that the higher rate of infection in males may be because males are capable of roaming farther than females, hence, a higher chance of coming in contact with other infected pigs, open human feces and infected carcasses. Gender-specific variations in cysticercosis prevalence among pigs have been documented in previous research. Hormonal and behavioral differences between male and female pigs can influence susceptibility to infection [19].

However, this could have been because more males were examined during the studies.

The prevalence of cysticercosis in pigs showed significant differences between dry and rainy seasons. Higher prevalence was recorded in Nukkai during the rainy season, indicating a potential seasonal influence on the transmission of the disease. Seasonal variations in pig-rearing practices and their impact on cysticercosis prevalence have been observed in other studies as well. Factors such as temperature, humidity, and feed availability can influence pig management practices and subsequently affect the prevalence of cysticercosis [16].

The study revealed that semi-intensive pig management had

a higher prevalence of cysticercosis in Iware, while intensive management showed a higher prevalence in Iware as well as Lamangoro. These differences may be attributed to variations in hygiene practices, feeding, or pig exposure to infection sources these findings supported the reports of [20]. Free roaming of pigs is known to be an important risk factor for infection of pigs with T. solium. In conclusion, these findings emphasize the need for targeted educational programs to increase awareness of cysticercosis among slaughterhouse workers and consumers. Additionally, the study highlights the importance of proper meat preparation techniques, especially in regions with a high prevalence of porcine cysticercosis. The influence of pig management practices on cysticercosis prevalence aligns with previous studies that have emphasized the role of pig housing, feeding, and hygiene in disease transmission. Improved management practices have been shown to reduce the risk of infection [21].

4. Conclusion

In conclusion, this study sheds light on the significant prevalence of porcine cysticercosis among slaughtered pigs in the North Senatorial Zone of Taraba State, Nigeria. Several key findings emerge from our investigation. A substantial proportion of slaughterhouse workers demonstrated limited awareness of cysticercosis, reflecting the need for targeted educational campaigns to enhance understanding of this parasitic disease and its transmission dynamics. The preference for short cooking methods among consumers is a cause for concern, as undercooked pork can potentially harbor viable cysticerci. This underscores the importance of promoting thorough cooking practices to mitigate the risk of transmission to humans. The research highlights the impact of seasonal variations on pig-rearing practices and cysticercosis prevalence. These findings underscore the need for adaptive strategies to address seasonal variations in disease transmission.

Furthermore, the study reveals location-specific variations in cysticercosis prevalence, suggesting that local factors such as sanitation, pig management, and cultural practices play a crucial role in disease dynamics. Tailoring interventions to specific locations is essential to effectively reduce the burden of cysticercosis. Gender-specific variations in cysticercosis prevalence among pigs are also evident, possibly influenced by hormonal and behavioral differences between male and female pigs. These findings emphasize the need for sex-specific approaches in disease management and prevention.

Lastly, pig management practices, including housing, feeding, and hygiene, significantly influence cysticercosis prevalence. Improved management practices have the potential to reduce the risk of infection, highlighting the importance of promoting better pig husbandry.

This study underscores the multifaceted nature of porcine cysticercosis prevalence in the North Senatorial Zone of Taraba State, Nigeria. Addressing this public health concern requires a holistic approach that encompasses education, cooking practices, seasonal adaptation, location-specific interventions, gender-specific considerations, and improved pig management practices. These findings contribute valuable insights to the ongoing efforts aimed at reducing the prevalence of cysticercosis and enhancing food safety in the region.

Authors' contributions

This work was carried out in collaboration among all authors. WBE conceived the idea and designed the study in collaboration with EOS and BWB. All authors participated in data collection, analysis, and writing and proof-reading of the final draft of the manuscript.

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