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Full Length Research Article

PREVALENCE, RISK FACTOR AND ECONOMIC LOSSES ASSOCIATED WITH BOVINE CYSTICERCOSIS IN SELECTED SLAUGHTER SLABS IN IGABI LOCAL GOVERNMENT AREA OF KADUNA STATE, NIGERIA

*Kadir I.A., D.M. Dibal and A.M. Haroun

Department of Biological Sciences, Postgraduate School, Nigerian Defence Academy, Kaduna State, Nigeria

*Corresponding Author Email Address: lkadir844@gmail.com

ABSTRACT
Bovine cysticercosis (BC) is a zoonotic infection affecting cattle, posing a significant public health challenge. This study analysed the prevalence, risk factors, and economic losses associated with BC across selected slaughter slabs (Kwata, Karshen Kwalta and Mando Slaughter Slabs) in Igabi LGA, Kaduna, Kaduna State. In this study, 300 cattle were inspected and 118 (37.7%) tested positive for BC, with specific occurrences 49% at Kwata, 43% at Karshen Kwalta, and 21% at Mando slaughter slabs. Statistical analysis revealed no significant association (P > 0.05) between BC and variables such as sex, age, body condition score, breed, or origin of the cattle. The anatomical distribution of *C. bovis* highlighted the masseter muscle as the most affected site (22.1%), while the heart was the least affected (7.1%). To confirm the identity of the parasitic larvae from inspected cattle carcasses, this study conducted standard microscopic and molecular analysis, revealing the presence of fluid-filled cysts with many having well-defined scolex, and two larvae (out of the three analysed by PCR) yielding a diagnostic band at 253bp. The extent of this economic loss calculated using data from findings about the rejection rate, cattle part/organ cost, and average cattle slaughtered annually, revealing an estimate of ₦92,295,500 annual economic loss resulting from BC infestation and condemnation.

Keywords: Bovine cysticercosis, Economic loss, Slaughter, Cattle.

INTRODUCTION

Parasitic diseases are widely regarded as an important threat associated with the safety and health of animal-derived food and result in significant financial losses for the agricultural sectors of nations worldwide (Ola-Fadunsin *et al.,* 2019). Bovine cysticercosis (BC), a zoonotic infection caused by the larval stage parasite *Cysticercus bovis* of the cestode *Taenia saginata* (beef tapeworm), is a huge public health concern with humans being the definitive host (El-Sayad *et al.,* 2021). Naturally, cattle get infected by drinking infected water or grazing in fields contaminated with human faces or sewage sediments containing *Taenia* eggs. In essence, this infection is acquired by cattle but results in human taeniasis following the consumption of raw or poorly cooked meat (Abay and Kumar, 2013; Laranjo-González *et al.,* 2016; Uys *et al.,* 2023). Within the intermediate host, the cysts of *C. bovis* are often found in the heart, kidney, masticatory muscles, oesophagus, liver, and diaphragm. An infected bovine carcass is sufficient for infecting about 8-20 people (Gholami *et al.,* 2020; El-Sayad *et al.* (2021).
Nigeria is among the leading sub-Saharan African countries in cattle production, and beef makes up a significant percentage of the total portion of meat consumed in Nigeria (Kubkomawa, 2017). Kaduna Metropolis reportedly has many abattoirs, with a significant number of them situated in Igabi Local Government Area (LGA) of Kaduna State (Nuhu *et al.,* 2021). Thus, the prevalence of a zoonotic infection is a serious concern. Studies have shown varying degrees of *Cysticercus bovis* prevalence worldwide, and Nigeria reportedly holds over 10% cysticercosis incidence, with Kaduna and Zaria having 4% incidence (Rabi'u and Jegede, 2010; Hiko and Seifu, 2019). This infection in cattle is a serious public health concern, as it has been established that humans are the definitive host of this parasite, with potential transmission leading to human taeniasis (Uys *et al.,* 2023). The economic burdens posed by BC infections have been highlighted, with records of severe economic losses resulting from infected meat condemnation, degradation, and freezing, as well as the decreased value of infected animals (Ola-Fadunsin *et al.,* 2019; Mazhani *et al.,* 2022).

Cattle production is a major economic activity, and beef is a significant part of Nigeria's diet. Thus, addressing zoonotic infections affecting cattle, such as BC, is critical for economic and public health outcomes (Mazhani *et al.,* 2022; Uys *et al.,* 2023). Early detection of this infection in intermediate hosts (cattle) is crucial, given the disease's zoonotic significance and associated financial losses (Gholami *et al.,* 2020). Unfortunately, cattle infected with *C. bovis* exhibit no symptoms, and the detection of cysts in carcasses is usually carried out during normal meat inspection by making various incisions into organs and muscles (Abay *et al.,* 2013). The objectives of this study were to determine the prevalence of bovine cysticercosis in cattle, confirm the identity of *Cysticercus bovis* present in infected cattle carcass from selected slaughter slabs, identify the risk factors associated with bovine cysticercosis and evaluate the economic losses in Igabi Local Government Kaduna, Kaduna State.

MATERIALS AND METHODS

Study Area

The study was conducted across three selected Slaughter slabs, namely; Kwata Slaughter Slab (in Rigasa), Karshen Kwalta Slaughter Slab, and Mando Slaughter Slab, all in Igabi Local Government Area (LGA). Igabi LGA is one of the 23 LGAs of Kaduna State. It is geographically located between latitude 10°47 0 N and longitude 7°46 0 E of the Greenwich Meridian (City Population, 2022). The region has a minimum temperature of 12.8°C and a high temperature of 35°C, and it is located around

650 meters above sea level. This LGA has three districts (Igabi, Rigachikun, and Rigasa), and is bordered by Giwa and Zaria LGA in the north, Soba to the east, Chikun and Kaduna North LGAs to the south, and Birnin Gwari LGA to the west. Igabi LGA has over 632,575 residents, and the main agricultural practices in this area are crop cultivation (maize, guinea corn, millet, cowpea, rice, etc.) and animal/livestock production (Oni *et al.,* 2023).

Ante-mortem and Post-mortem Examinations

A comprehensive ante- and post-mortem examinations for the sampled cattle was conducted across the study sites. Prior to slaughtering, a total of 300 cattle (100 from each slaughter slab) was selected using random sampling method for the ante-mortem examination. These animals were categorized based on their gender, age, body condition (BCS), breed, and origin. Cattle that were ≤ 5 years classified as adults and those >5 years classified as old. Hence, 262 adult cattle and 38 old cattle were randomly selected for this study. Based on the animal body condition, sampled cattle were classified as either good or bad. The breeds of animals brought to the slaughter slabs included White Fulani, Red Bororo, Sokoto Gudali, Umito Flai, and Kuri. These cattle were identified to have origins from either Nigeria or Niger. An identifying number was assigned to each sampled animal during the ante-mortem assessment. Following slaughter, *C. bovis* (post-mortem) identification across carcasses was carried out using standard visual and molecular analysis (Fesseha and Asefa, 2023).

Visual Inspection and Cysts Classification

The detection of *C. bovis* cysts was performed through a careful meat inspection routine across selected slaughter slabs. This procedure involved the visual inspection of the entire cattle carcass, followed by specific inspections of cut muscles and organs, mostly in selected predilection sites such as the heart, masseter muscles, and the tongue. These specimens were further subjected to proper parasitological investigation. Each suspected cyst was further subjected to microscopic analysis using the procedure described by El-Dakhly *et al.,* (2023). Briefly, the suspected cyst was dissected carefully, placed between two slides, and examined with a low-power microscope. Viable cysts were indicated by the presence of four suckers, and these were preserved in 70% alcohol for analysis using molecular techniques.

MOLECULAR ANALYSIS

DNA Extraction

The DNA extraction from three representative viable cysts from across the selected slaughter slabs was carried out using Serum Viral DNA/RNA Extraction kit, following the manufacturer's protocol. The extracted DNA quality was confirmed using Nanodrop absorption spectroscopy (Gracia-Alegria *et al.,* 2020).

Amplification Using Polymerase Chain Reaction

The amplification of *C. bovis* genes was performed using forward ('5-GGGTGCTGGTATAGGGTGGACT−3') and reverse ('5ACGTAAATAAATAAGCCCACAATATT − 3') primers for COI gene detection. The PCR amplification was carried out in a total reaction volume of 25µL, consisting of 2µL of template DNA, 12.5µL of EasyTaq PCR SuperMix, 1µL (each) of forward and reverse primers, and 8.5µL of nuclease free water (El-Dakhly *et al.,* 2023).

Agarose Gel Electrophoresis

The separation and visualization of the DNA products were carried out using agarose gel electrophoresis to determine the DNA fragment size. Agarose (1.5%) was used for this analysis, prepared by dissolving 1.5g of agarose powder in 100 mL of Tris/Borate/EDTA (TBE) buffer. The mixture was heated until the agarose fully dissolved, and then allowed to cool to a temperature of 45-50°C. The cooled agarose solution was then poured into a gel casting tray fitted with a comb to create wells for sample loading. After solidification, the comb was carefully removed, leaving appropriately sized wells in the gel. The amplified PCR products were mixed with a loading dye and deposited into the wells. A DNA ladder (molecular weight marker) was also loaded into one well to serve as a reference for determining the sizes of the PCR-amplified fragments. Nuclease-free water was used as a negative control for each PCR run to confirm the specificity of the amplification (El-Sayad *et al.,* 2021; Dagher and Shaher, 2023).
The gel electrophoresis was carried out at a constant voltage (typically 80-100V) until the dye front migrated to about one-third of the gel length. Following the completion of electrophoresis, the gel was stained with ethidium bromide and placed under ultraviolet (UV) light at 360 nm to visualize the DNA bands. The expected DNA fragments were observed, with the target band size identified by comparing it to the reference DNA ladder (El-Sayad *et al.,* 2021).

Questionnaire Design and Administration

A questionnaire was designed and issued to notable individuals within each sampled slaughter slab to collect information about awareness of cysticercosis, exposure to risk factors, management practices, environmental characteristics, and health and sanitation behaviour of participants. These risk factors were identified based on existing BC literatures, and questionnaires administered by direct interviews. Informed consent was gotten from participants prior to the interview (Rubiola *et al.,* 2021). The questionnaire was divided into six (6) parts, consisting of a total of twenty-three (23) questions. Participants were interviewed accordingly in English and Hausa.

Economic Loss Analysis

The extent of cattle condemnation was determined through a survey, as a partial reflection of incurred financial losses resulting from BC infestation of cattle. This survey was incorporated into the questionnaire that was administered. The economic loss analysis was further determined using the method described by Solomon and Alemu (2019). Briefly, the financial losses attributed to organ condemnation was analysed by data of the slaughter slab's annual average slaughter capacity, the average cost of each cattle organ sold within Igabi LGA, and the rejection rates of each organ. The average market price of organs used in this study was determined by interviewing different butchers across the slaughter slabs. The calculation of the financial loss from cattle condemnation was further calculated using the formula:

EL = Σsrx * Coy * Roz

Where:
EL = Annual economic loss estimated due to organ condemnation.
Σsrx = Annual cattle slaughter rate of the slaughter slab.
Coy = Average cost of each cattle organ/part.
Roz = Condemnation rate of each cattle organ/part.
The rejection rates for cattle was analysed by determining the total number of organs inspected (N) and the number of rejected organs (R):

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Rejection Rate (%) = (N/R) ×100

Data Analysis

All data collected from the slaughtered cattle during the study were systematically recorded and organised in a Microsoft Excel worksheet (version 2016). The data was then analysed using the IBM Statistical Package of Social Sciences (SPSS) version 23. Descriptive statistical methods were employed to generate percentages and frequencies, summarising the study's data. Pearson's Chi-square (X^2) test was used to assess the associations between cattle characteristics (such as sex, age, origin, and body condition score) and the occurrence of *Cysticercus bovis* infection. A significance level of $P < 0.05$ was applied, i.e., a *P*-value less than or equal to 0.05 was considered statistically significant.

RESULTS

Prevalence of Bovine Cysticercosis

In this study, a total of 300 cattle were inspected across three study areas; Kwata Slaughter Slab, Karshen Kwalta Slaughter Slab, and Mando Slaughter Slab. The pooled prevalence of cysticercosis recorded was 37.7%. This result at 95% confidence interval (32.2% - 43.2%) reveals that out 100 cattle inspected in each slaughter slab, up to 49 Kwata = 49; Karshen Kwalta = 43; Mando = 21) were affected with bovine cysticercosis.

Table 1: Overall Prevalence of Bovine Cysticercosis across Selected Slaughter Slabs in Igabi LGA

Site	Sample Size	Positive Cases	Site Prevalence	Pooled Prevalence (%)	95% CI		
					Margin of Error	Lower CI	Upper CI
Kwata	100	49	49%	37.70%	5.48%	32.22%	43.18%
Karshen Kwalta	100	43	43%				
Mando	100	21	21%				
Total	**300**	**113**					

Occurrence of Bovine Cysticercosis in Kwata Slaughter Slab

This study recorded a 49% overall prevalence of cysticercosis in Kwata Slaughter slab, Rigasa. Out of 31 males and 69 females slaughtered and inspected, 35.5% of the males and 62.1% of the females were recorded positive for *C. bovis.* In terms of age distribution, 78 adults and 22 older cattle were inspected, with a prevalence of 46.2% and 59.1%, respectively. The prevalence of *C. bovis* based on body condition score, breed, and origin is detailed in Table 2. Statistical analysis revealed no significant association (P > .05) between the prevalence of *C. bovis* and the sex, age, body condition score, breed, or origin, of the inspected cattle

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Table 2: Occurrence of Bovine Cysticercosis in Kwata Slaughter Slab

Variables	Categories	Total No. of Animals Examined	No. of Positive Animals	Occurrence (%)	Chi-square	*P*-value
Sex	Male	31	11	35.5	3.284	0.07
	Female	69	38	62.1		
Age	Adult	78	36	46.2	1.149	0.284
	Old	22	13	59.1		
Body Condition Score	Good	94	46	48.9	0.003	0.96
	Bad	6	3	50		
Breed	White Fulani	90	44	48.9	4.006	0.405
	Red Bororo	6	3	50		
	Kuri	2	0	0		
	Umito Flai	1	1	100		
	Sokoto Gudali	1	1	100		
Origin	Nigeria	94	46	48.9	0.003	0.999
	Niger	4	2	50		
	Chad	2	1	50		

Occurrence of Bovine Cysticercosis in Karshen Kwalta Slaughter Slab

In Karshen Kwalta Slaughter Slab, an overall prevalence of 43% was recorded. Considering the sex population (43 males and 57 females) of the slaughtered and inspected animals, 51.2% males and 36.8% females tested positive for *C. bovis.* Out of 81 adults and 19 older cattle inspected, a prevalence of 35% and 8%, respectively, was recorded. Further information on the prevalence of BC based on body condition score, breed, and origin is highlighted in Table 3. Statistical analysis revealed no significant association (P > .05) between the prevalence of *C. bovis* and the sex, age, body condition score, breed, or origin, of the inspected cattle.

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Table 3: Occurrence of Bovine Cysticercosis in Karshen Kwalta Slaughter Slab

Variables	Categories	Total No. of Animals Examined	No. of Positive Animals	Occurrence (%)	Chi-square	*P*-value
Sex	Male	43	22	51.2	2.051	0.152
	Female	57	21	36.8		
Age	Adult	81	35	43.2	0.008	0.930
	Old	19	8	42.1		
Body Condition Score	Good	92	42	45.7	3.300	0.069
	Bad	8	1	12.5		
Breed	White Fulani	87	41	47.1	4.657	0.097
	Red Bororo	7	1	14.3		
	Kuri	6	1	16.7		
Origin	Nigeria	92	41	44.6	1.441	0.487
	Niger	7	2	28.6		
	Chad	1	0	0		

Occurrence of Bovine Cysticercosis in Mando Slaughter Slab
At the Karshen Kwalta Slaughter Slab, the overall prevalence of bovine cysticercosis was found to be 21%. When analyzing the data based on the sex of the slaughtered and inspected cattle, which consisted of 43 males and 57 females, it was observed that 20.9% of the male cattle tested positive for *C. bovis*, compared to 21.1% of the females. Age-specific analysis of the cattle revealed that out of the 99 adult cattle inspected, 20.2% were positive for *C. bovis*. Further examination of the data, detailed in Table 4, includes the prevalence of *C. bovis* according to other factors such as body condition score, breed, and the cattle's origin. While descriptive statistics show variability in prevalence rates across different subgroups, there were no significant association (P > 0.05) recorded.

Table 4: Occurrence of Bovine Cysticercosis in Mando Slaughter Slab

Variables	Categories	Total No. of Animals Examined	No. of Positive Animals	Occurrence (%)	Chi-square	*P*-value
Sex	Male	43	9	20.9	0.000	0.988
	Female	57	12	21.1		
Age	Adult	99	20	20.2	3.800	0.051
	Old	1	1	100		
Body Condition Score	Good	94	20	21.3	0.072	0.788
	Bad	6	1	16.7		
Breed	White Fulani	93	20	21.5	1.353	0.508
	Red Bororo	4	0	0		
	Sokoto Gudali	3	1	33.3		
Origin	Nigeria	97	21	21.6	0.822	0.663
	Niger	2	0	0		
	Chad	1	0	0		

***Cysticercus bovis* Cyst Distribution among Inspected Cattle Organs**
This study inspected a total of 300 cattle carcass across the selected slaughter slabs, out of which an overall prevalence of 37.7% (113 positive cases) was recorded. Detailed prevalence rates recorded for the different carcass parts sampled is detailed in Table 5. The Masseter muscle showed the most prominent case of infection, accounting for 22.1% of the cases, compared to the heart that had the least number of cysticerci present, accounting for only 7.1%.

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Table 5: Anatomical Distribution of *C. bovis* Cysts among Inspected Cattle Organs

Variable	Categories	Positive	Occurrence
	Liver	15	13.3%
	Heart	8	7.1%
	Tongue	22	19.5%
Organs			
	Masseter Muscle	25	22.1%
	Diaphragm	19	16.8%
	Triceps	24	21.2%

Microscopic Analysis of *C. bovis* in Sampled Carcass Parts
In this study, the presence of *C. bovis* was recorded in various organs, and these were further analysed using a microscope to assess the features of the cysts (Figure 1). In most cases, the cysts appeared as fluid-filled with well-defined scolex. These cysts were oval or round-shaped, measuring about 8 – 10mm in diameter. The microscopic analysis revealed that there were twenty (20) viable cysts in the carcasses sampled from Kwata Slaughter Slab, thirty-one (31) from Karshen Kwalta Slaughter Slab, and thirteen (13) from Mando Slaughter Slab.

Molecular Detection and Confirmation of *C. bovis*
The presence of *C. bovis* was confirmed by PCR detection of the cytochrome c oxidase subunit I (COI) gene. Two samples out of the three larvae examined produced a positive result, with amplicon size of 253 base pairs (bp).

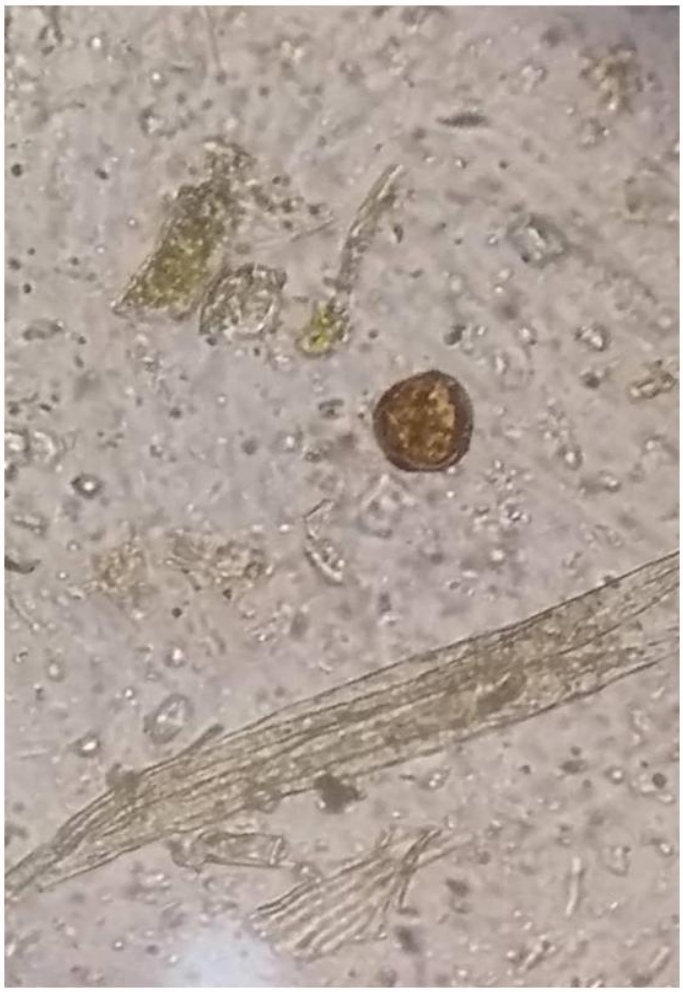

Figure 1: Microscopic Appearance of Taenia egg in Sampled Carcasses

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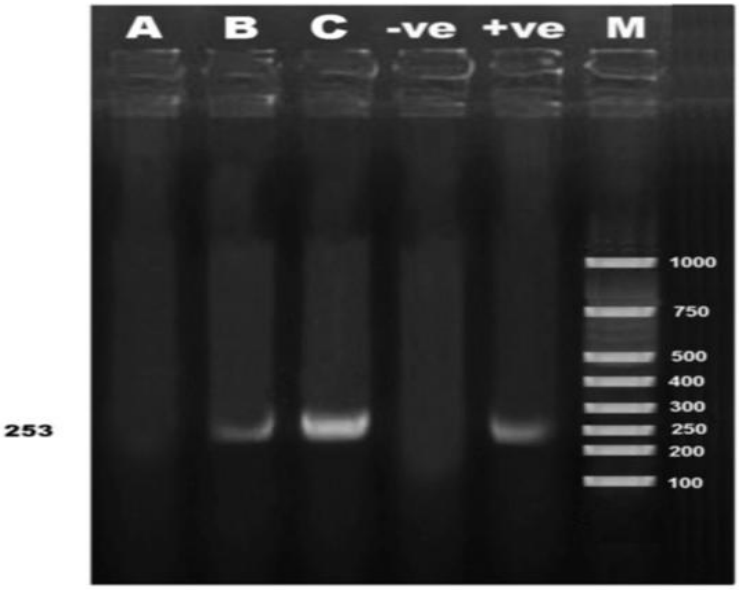

Plate I: Amplified *C. bovis* DNA.
Keys: Lane A = Negative
Lane B, C = Poaitive for COI (253bp)
Lane -ve = Negative control
Lane +ve = Positive control
Lane M = Molecular ladder (100bp)

Risk Factor Analysis

This study analysed the risk factors associated with the sampled slaughter slabs infected with BC; this was carried out by analysing the response from the study questionnaire. The socio-demographic characteristics of participants is presented in Table 6. A significant portion of the study population, which consisted of all males (100%), belonged to two main age groups: those aged 20 to 29 (28.1%) and those aged 50 and above (29.8%). 22.8% and 19.3% of participants were in the 30- 39- and 40-49-year-old age groups, respectively. Only 12.3% of respondents identified as consumers, whereas the rest of the respondents (87.7%) were butchers. In terms of educational achievement, 33.3% of participants had only completed primary school, while 67.7% had completed secondary school. Furthermore, the all respondents captured in this study admitted to living in rural areas.

Participants had a modest general understanding of bovine cysticercosis, with 56.1% expressing awareness and 43.9% reporting no prior knowledge. Based on occupation, 14.3% of customers knew about the condition, while 62% of butchers relayed their awareness. Also, participants with only primary school certificates had the highest knowledge level (89.5%), whereas participants who attained secondary school education had a significantly lower awareness level (39.5%). There was significant difference recorded between occupation and BC awareness, as well as educational level and BC awareness ($p<0.05$). The result is presented in Table 7.

Table 6: Socio-Demographic Characteristics of Participants

Characteristics	Frequency	Percentage (%)
Age		
20 – 29	16	28.1
30 – 39	13	22.8
40 – 49	11	19.3
50 and above	17	29.8
Gender		
Male	57	100
Occupation		
Butcher	50	87.7
Consumer	7	12.3
Level of Education		
Primary	19	33.3
Secondary	38	67.7
Area of Residence		
Rural	57	100

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Table 7: Bovine Cysticercosis Awareness among Demographics

Characteristics	Aware	Not Aware	Total	Chi-Square	*P*-value
Occupation					
Butcher	31 (62%)	19 (38%)	50 (87.7%)		
Consumer	1 (14.3%)	6 (85.7%)	7 (12.3%)	5.677	0.017
Total	32 (56.1%)	25 (43.9%)	57 (100%)		
Level of Education					
Primary	17 (89.5%)	2 (10.5%)	19 (33.3%)		
Secondary	15 (39.5%)	23 (60.5%)	38 (66.7%)	12.861	0.000
Total	32	25	57 (100%)		

Highlighted Risk Factors Associated with Bovine Cysticercosis

In this study, numerous risk variables that contribute to bovine cysticercosis across the sample sites were discovered by the investigation. A good number of the respondents (87.7%) reported that cattle were not routinely dewormed. Other reported risk factors were that the cattle were exposed to human waste (73.3%), humans ate raw or undercooked meat (45.6%), and cattle drank untreated water (28.1%). Furthermore, all participants (100%) in this investigation reported the issue of open defecation as a risk factor.

Sanitation Practices and Public Health Impacts

The hygiene and sanitation practices reported during this investigation is presented in Table 8. This study revealed that 86% of participants admitting to not following set guidelines for slaughtering or selling meat, while just 14% confirmed doing so. Slaughter slab hygiene report revealed 33.3% of respondents not knowing the proper hygiene procedures and 66.7% of respondents stating that occasional cleaning was necessary. Nonetheless, all respondents (100%) stated that veterinary personnel routinely examined animals for illnesses and regular health inspections were widely reported (87.7%); this result is presented in Table 9.

This study further examined the health risk perception of bovine cysticercosis from the survey participants, and this is shown in Table 10. When asked whether BC poses a risk to consumers, only 26.3% believed it did, while 73.7% thought it posed no risk at all. However, all respondents (100%) acknowledged that improved sanitation could reduce the risk of BC.

Table 8: Common Highlighted Risk Factors of *Bovine cysticercosis*

Variable	Frequency	Percentage (%)
Human Consumption of Undercooked/Raw Beef	26	45.6
Cattle Drinking Untreated Water	16	28.1
Cattle are not dewormed	50	87.7
Cattle Exposed to Human Faeces	42	73.3%
Open Defecation from Practices Amongst Humans in the Area	57	100%

Table 9: Health and Sanitation Practices across Slaughter Slabs

Variable	Frequency	Percentage (%)
Following Guidelines for Slaughtering/Selling Meat		
Yes	8	14
No	49	86
Measures for Slaughter Slab Hygiene		
Occasional Cleaning	38	66.7
Not Sure	19	33.3
Regular Health Inspection at the Slaughter		
Yes	50	87.7
No	7	12.3
How often Veterinary Officers Check the Animals for Diseases		
Regularly	57	100%

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Table 10: Health Risk Perception of *Bovine cysticercosis*

Variable	Frequency	Percentage (%)
Is BC a risk to consumers?		
Yes	15	26.3
No	42	73.7
What actions reduces the risk of BC?		
Improved Sanitation	57	100

Economic Loss Assessment

The study revealed that respondents unanimously (100%) indicated that the economic impact of BC on their businesses or livelihoods was "minimal." Despite this, 56.1% of respondents confirmed that BC infestation was the cause of their cattle sale's losses, whilst 43.9% said that they had no such losses. This result is presented in Table 11.

Table 11: Economic Impact of Bovine Cystercicosis

Variable	Frequency	Percentage (%)
Economic Impact of BC on Businesses/Livelihood		
Minimal	57	100
Losses in Cattle Sales Due to this Disease (BC) Outbreak		
Yes	32	56.1
No	25	43.9

Rate of Organ Condemnation and Corresponding Financial Loss (Annually)

Following a brief interview of the butchers across the three selected slaughter slabs, it was revealed that an average of 173,000 cattle slaughtered each year. The initial survey revealed that there was minimal economic impact of BC across these slaughter slabs; hence, the rejection rates are partial. The rejection rates, as revealed by butchers, as well as the average market price per organ, and the calculated annual financial loss per organ is presented in Table 12 below.

Table 12: Annual Financial Loss Resulting from Cattle Organs Condemnation

Affected Organs	Partial Rejection Rate (%)	Average Market Price Per Organ (₦)	Annual Financial Loss Per Organ (₦)
Liver	0.5	40,000	34,600,000
Heart	0.5	35,000	30,275.000
Tongue	0.4	6,000	4,152,000
Masseter Muscle	0.1	42,000	7,266,000
Diaphragm	0.1	10,000	1,730,000
Triceps	0.3	27,500	14,272500
Total			**92,295,500.**

DISCUSSION

This highlights a significant level of burden within the study area, which is significantly higher than the 3.3% prevalence reported by Sabuwa *et al.* (2020) in a study conducted in Lafia (Niger State). However, in a study conducted by Hailemariam *et al.* (2013), a higher BC prevalence of 92.7% was recorded across selected cities in Ethiopia. The prevalence rates recorded in this study varied across individual slaughter slabs, with Kwata Slaughter Slab having the highest rate (49%), followed by Karshen Kwalta Slaughter Slab (43%), and then Mando Slaughter Slab having the lowest recorded prevalence rate (21%). The variations between recorded rates in previous studies and the current rates seen across each selected slaughter slab in this study are most likely due to the sample sizes, agroclimatic conditions, management systems, sanitary practices, and routine inspection (Fesseha and Asefa, 2023; Kassaw and Geto, 2024).

The Chi-square analysis from this study shows that there was no significant association ($P > 0.05$) between the prevalence of *C. bovis* and the sex, age, body condition score, breed, or origin, of the inspected cattle. This finding is consistent with the study conducted in Central and North-Eastern Ethiopia (Fesseha and Asefa, 2023; Kassaw and Geto, 2024). However, this was not the case with the outcome of the study conducted by Qadeer (2008) in Jos, as there was a significant association ($P < 0.05$) between the age and sex distribution of slaughtered cattle that tested positive for *C. bovis*. The highlighted case of no significant difference in this study can be linked to equal susceptibility, giving the likelihood of all cattle becoming infected with *C. bovis* upon exposure. On the other hand, the reasons for these varied significances among different studies may be due to the ratio of female to male animals sampled, since mostly male cattle are slaughtered and the females kept for milk production (Fesseha and Asefa, 2023).

The prevalence rates of *C. bovis* in other sampled parts of cattle carcasses recorded include the diaphragm with 19 (16.8%) positives, the liver with 15 (13.3%) positives, and the least rate recorded in the heart having 8 (7.1%) positive cases. However, this

result does not align with the study of Fesseha and Asefa (2023), which also recorded the tongue (42.9%) as the most affected organ with *C. bovis* cysts. In a study conducted by Rabi'u and Jegede (2010) in Kano, the tongue was also highlighted to have the highest infestation rate (13%) compared to other organs. This was not the case with the result from a study conducted by Kassaw and Geto (2024) that recorded the liver (65.21%) to be the most infested. One common thing found across these highlighted studies that aligns with this study is the presence of the cyst across predilection sites, such as the masseter, tongue, diaphragm, heart, and liver. This anatomical distribution of the cysts may be attributed to the ability of infected *T. saginata* eggs to hatch into oncospheres and penetrate the cattle's intestinal walls, with the larva gaining passage into the circulatory system (Tegegne *et al.,* 2018).

The microscopic analysis in this study confirmed the presence of viable cysts (20 from Kwata, 31 from Karshen Kwalta, and 13 from Mando slaughter slabs) with unique characteristics such scolex structures and translucent vesicles in the sampled cattle carcasses. These were further backed up with proper molecular analysis using PCR that revealed an amplicon band size of 253bp for *C. bovis* detected in two out of the three representative samples subjected to molecular identification. This result aligns with the findings from the study conducted by El-Dakhly *et al.* (2023). This could be due to the fact that the cyst observed under microscope may appear viable but could have non-intact or degraded DNA, making PCR detection unsuccessful and also the target gene or DNA sequence used for PCR may have mutations or variations that prevent primer binding, leading to false negatives.
The highlighted risk factors in this study were analysed from the responses of participants in a survey where the study population were entirely male. Notably, all respondents lived in rural areas, which are often characterized by limited access to sanitation and healthcare resources. This socio-demographic analysis was necessary to understand the responses from the study population and aid in the proper identification of BC risk factors and variations that exist across different groups. Out of 57 respondents, only 32 (56.1%) of them were aware of bovine cysticercosis and the levels of awareness were significantly influenced by their occupation and educational level (P<0.05). Butchers were revealed to have higher awareness (62%) compared to consumers (14.3%), and participants with primary school education were generally more aware (89.5%) than those with secondary education (39.5%). The higher percentage of butchers aware of this parasitic infestation appears logical since they are more involved in directly handling cattle and their carcasses. On the other hand, this study's findings about the educational qualification of participants aware of BC can be attributed to the fact that observational abilities and not necessarily formal education remain the commonest means of identifying animal diseases amongst key actors in rural livestock handling (Majiwa *et al.,* 2023).

Considering the risk factors associated with BC, this study highlighted various factors, such as cattle drinking untreated water (28.1%), humans consuming raw or poorly cooked meat (45.6%), exposure of cattle to human faeces (73.3%), lack of deworming practices (87.7%), and open defecation (100%). This result aligns with previous studies that had found these practices to highly facilitate the lifecycle of *Taenia saginata*, perpetuating cysticercosis transmission (Laranjo-Gonzalez *et al.,* 2016; Alves *et al.,* 2017; Rubiola *et al.,* 2021). These highlighted risk factors were further supported by the health and sanitation practices recorded across sampled slaughter slabs in this study. Suboptimal sanitation practices were recorded with 86% of participants not adhering to proper guidelines for meat handling and 66.7% only cleaning facilities occasionally, even though they all confirmed that veterinary officers were regularly conducting health inspections. In line with this result, Ovuru *et al.* (2023) highlighted the need for addressing poor environmental hygiene and sanitation practices of butchers and abattoir workers to reduce pathogenic contaminants, including parasites, from slaughterhouses.
In this study, the economic impact was reported based on an initial survey conducted across three slaughter slabs and further calculation of the financial loss estimate based on the rejection rates of affected organs, their market price, and the average number of cattle slaughtered yearly. This research revealed that 32 (56.1%) participants confirmed the potential losses in cattle sales due to BC outbreak, even though the economic impact was said to be minimal. The limited economic impact from these abattoirs may be due to the fact that there is usually little or no symptoms of this infection in cattle (Dermauw *et al.,* 2018). The rejection rates recorded in this study were 0.5% for liver, 0.5% for heart, 0.4% for tongue, 0.1% for the masseter muscle, 0.1% for the diaphragm, and 0.3% for the triceps. Based on the financial analysis in this study, about ₦92,295,500 is lost annually due to BC infestation.

Conclusion

In conclusion, this study recorded a 37.7% prevalence of bovine cysticercosis (113 cases, 95% CI: 32.2%-43.3%) with Kwata (49%), Karshen Kwalta having (43%), and Mando (21%) BC prevalence. No significant association ($p > 0.05$) was found between *C. bovis* prevalence and the cattle sex, age, body condition, breed, or origin.
Microscopic examination confirmed *C. bovis* in inspected cattle carcasses, revealing fluid-filled cyst with well-defined scolices. Molecular analysis of three larvae detected the diagnostic (COI) gene (253bp) in one sample.
The risk analysis of bovine cysticercosis revealed that a modest number of individuals (56.1%) were aware of BC.
Furthermore, this study provided insights on the economic losses resulting from BC infestations from cattle investigated across the different study sites. It reveals an estimate of ₦92,295,500 annual economic loss resulting from BC infestation and condemnation..

REFERENCES

Abay, G., and Kumar, A. (2013). Cysticercosis in Cattle and its Public Health Implication in Mekelle City and Surrounding Areas, Ethiopia. *Ethiopia Veterinary Journal, 17*(1), 31 – 40.

Alves, W.C., Rossi, G.A.M., Lopes, W.D.Z., Almeida, H.M.S., Mathias, L.A., Vidal, A.M.C., and Soares, V.E. (2017). Geospatial Distribution and Risk Factors for Bovine Cysticercosis in the State of Rondônia, Brazil. *Pesquisa Veterinária Brasileira, 37*(9), 931–936. doi:10.1590/s0100-736x2017000900006

Beyene, T., and Hiko, A. (2019). Zoonotic metacestodes and associated financial loss from cattle slaughtered at Yabello municipal abattoir, Borana-Oromia, Ethiopia. *Parasite Epidemiology and Control*, *5*, e00096. https://doi.org/10.1016/j.parepi.2019.e00096

City Population. (2022). Igabi (Local Government Area, Nigeria). https://www.citypopulation.de/en/nigeria/admin/kaduna/NGA019004__igabi (Accessed: 14th November, 2024).

Dagher, I. J., and Shaher, K. W. (2023). Isolation and identification of Lactobacillus in the stomach of honey bees and recording a type of bacteria. *Euphrates Journal of Agriculture Science, 15*(1), 335–341.

Dermauw, V., Dorny, P., Braae, U.C., Devleesschauwer, B., Robertson, L.J., Saratsis, A., and Thomas, L.F. (2018). Epidemiology of *Taenia saginata* taeniosis/cysticercosis: a systematic review of the distribution in southern and eastern Africa. *Parasitic Vectors, 11*(1), 578. https://doi.org/10.1186/s13071-018-3163-3

El-Dakhly, K.M., Hany, S.A., Arafa, W.M., Abdel-Fatah, O.R., Abdel-Atty, N.S., and El-Nahass, E. (2023). The Prevalence and Molecular Detection of Bovine Cysticercosis and Its Impact on Slaughtered Cattle in Egypt. *Journal of Parasitic Diseases,* PREPRINT (Version 1). https://doi.org/*10.21203/rs.3.rs*-2764851/*v1*

El-Sayad, M.H., Farag, H., El-Taweel, H., Fadly, R., Salama, N., Ahmed, A.A.E. and El-Latif, N.F.A. (2021). *Cysticercus bovis* in cattle slaughtered in North Egypt: Overestimation by the visual inspection method. *Veterinary world*, *14*(1), 155–160. https://doi.org/10.14202/vetworld.2021.155-160

Fesseha, H., and Asefa, I. (2023). Prevalence and Associated Risk Factors of *Cysticercosis bovis* in Bishoftu Municipal Abattoir, Central Ethiopia. *Environmental Health Insights*, *17*, 11786302231164298. https://doi.org/10.1177/11786302231164298

Gholami, N., Mosayebi, M., Dehghan Rahim Abadi, P., Rasmi Atigh, H., Sedaghat, R., Naji Zadeh, M. H., and Farahani, M. (2020). Bovine cysticercosis in feedlot cattle in central region of Iran. *Journal of parasitic diseases: official organ of the Indian Society for Parasitology*, *44*(1), 25–30. https://doi.org/10.1007/s12639-019-01157-9

Gracia-Alegria, A.M., Anduri-Corona, I., Perez-Martinez, C.J., Corella-Madueno, M.A.G., Rascon-Duran, M. L., and Astiazaran-Garcia, H. (2020). Quantification of DNA through Nanodrop Spectrophotometer: Methodological validation using standard reference material and Sprague Dawley rat and human DNA. *International Journal of Analytical Chemistry, 2020*, 1–9.

Hailemariam, Z., Nakao, M., Menkir, S., Lavikainen, A., Iwaki, T., Yanagida, T., Okamoto, M., and Ito, A. (2013). Molecular Identification of Species of *Taenia* Causing Bovine Cysticercosis in Ethiopia. *Journal of Helminthology,* 1 – 5. doi:10.1017/S0022149X13000138

Hiko, A., and Seifu, B. (2019). Spatiotemporal distribution and economic loss associated with bovine cysticercosis and human taeniasis in Ethiopia. *Parasite Epidemiology and Control*, *4*, e00078. https://doi.org/10.1016/j.parepi.2018.e00078

Kassaw, S., Geto, A. (2024). Prevalence, Anatomical Cyst Distribution and Economic Significance of *Cysticercus bovis* in Cattle Slaughtered at Kombolcha Elfora Meat Factory, North-Eastern Ethiopia. *Journal of Veterinary Science and Technology, 15*(2), 2024.

Kubkomawa, H.I. (2017). Indigenous Breeds of Cattle, their Productivity, Economic and Cultural Values in Sub-Saharan Africa: A Review. *International Journal of Research Studies in Agricultural Sciences, 3*(1), 27 – 43. http://dx.doi.org/10.20431/2454-6224.0301004

Laranjo-González, M., Devleesschauwer, B., Gabriël, S., Dorny, P., and Allepuz, A. (2016). Epidemiology, impact and control of bovine cysticercosis in Europe: a systematic review. *Parasites Vectors, 9*, 81. https://doi.org/10.1186/s13071-016-1362-3

Majiwa, H., Bukachi, S.A., Omia, D., and Fevre, E.M. (2023). Knowledge, Perceptions, and Practices around Zoonotic Diseases among Actors in the Livestock Trade in the Lake Victoria Crescent Ecosystem in East Africa. *Frontiers Public Health*, *11*, 1199664. doi: 10.3389/fpubh.2023.1199664

Mazhani, B., Masitha, E., Ntwaetsile, M., Thutwa, K., and Sehularo, K. (2022). Distribution of Bovine Cysticercosis Prevalence in the Southeastern Districts of Botswana deom 2015 to 2016. *Veterinary World, 15*(2), 368 – 373.

Nuhu, H., Dantudu, A.S.U., and Bello, M. (2021). Assessment of Abattoirs in Kaduna Metropolis, Kaduna State, Nigeria. *International Journal of Environmental Studies and Safety Research, 6*(1), 1 – 19.

Ola-Fadunsin, S.D., Uwabujo, P.I., Halleed, I.N., and Richards, B. (2019). Prevalence and Financial Loss Estimation of Parasitic Diseases Detected in Slaughtered Cattle in Kwara State, North-Central Nigeria. *Journal of Parasitic Diseases, 44,* 1 – 9. https://doi.org/10.1007/s12639-019-01154-y

Oni, B.O., Akure, C.O., Adamu, S., Agbomaka, F.I., and Balogun, O.S. (2023). Socio-Economic Factors Affecting the Production of Okra among Rural Farmers in Igabi Local Government Area of Kaduna State, Nigeria. *FUDMA Journal of Sciences, 7*(6), 206 – 210. https://doi.org/10.33003/fjs-2023-0706-2186

Ovuru, K.F., Izah, S.C., Ogidi, O.I., Imarhiagbe, O., and Ogwu, M.C. (2023). Slaughterhouse Facilities in Developing Nations: Sanitation and Hygiene Practices, Microbial Contaminants and Sustainable Management System. *Food Science and Biotechnology, 33,* 519 – 537.

Qadeer M.A. (2008). Prevalence of Bovine Cysticercosis in Jos Abattoir, Nigeria. *Animal Research International, 5*(1), 777 – 779.

Rabi'u B.M., and Jegede, O.C. (2010). Incidence of Bovine Cysticercosis in Kano State, North-Western Nigeria. *Bayero Journal of Pure and Applied Sciences, 3*(1), 100-103.

Rubiola, S., Moroni, B., Carisio, L., Rossi, L., Chiesa, F., Martano, G., Cavallo, E., and Rambozzi, L. (2021). Risk Factors for Bovine Cysticercosis in North-West Italy: A Multi-Year Case-Control Study. *Animals*, *11*(11), 3049. https://doi.org/10.3390/ani11113049

Sabuwa, A.B., and Baba, M.K. (2021). The Prevalence of *Cysticercus bovis* in Cattle Slaughtered at Lafia Central Abattoir, North-Central, Nigeria. *EAS Journal of Veterinary Medical Science, 2*(1), 1-4.

Solomon, T., and Alemu, B. (2019). Economic loss caused by organ condemnation in cattle slaughtered at Hawassa Municipal Abbatoir, Southern Ethopia. International Journal of Advanced Research in Biological Sciences, 6(2), 85-93.

Tegegne, A., Hiko, A., and Elemo, K.K. (2018). Bovine Cysticercosis and Human Taeniasis: Animal–Human Health and Economic Approach with Treatment Trends in Kombolcha Town, Wollo, Ethiopia. *International Journal of One Health, 4* (1), 15-21. DOI:10.14202/IJOH.2018.15-21

Uys, M., Fosgate, G. T., and Seguino, A. (2023). Bovine cysticercosis epidemiology and the economic impact of the triceps brachii incision in a South African export abattoir. *Preventive Veterinary Medicine*, *220*, 106050. https://doi.org/10.1016/j.prevetmed.2023.106050