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Retrospective Study of Prevalence and Economic Losses due to Bovine Tuberculosis in Gombe Township Abattoir, Northeastern-Nigeria.

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ABSTRACT

Bovine tuberculosis (bTB) is a chronic zoonotic disease of cattle associated with high economic losses in beef and dairy farms in most developing countries including Nigeria. A 10-year retrospective study (2008-2017) using post-mortem (PM) meat inspection records of slaughtered cattle at the Gombe township abattoir (GTA) to estimate the prevalence and economic losses from bTB was investigated. The current prices of meat/kg in Naira currency (₦) and US Dollars ($) equivalent were determined. A total of 178,847 cattle were examined post-slaughter, A total of 1,722 (0.96%) were affected with bTB lesions. Lungs were the organs most affected, A higher prevalence of 1,120 (1.06%) of bTB was recorded in the wet season compared with dry season with 602 (0.83%). There were statistically significant associations ($p<0.05$) between annual, seasonal, temporal factors and bTB prevalence. The economic losses associated with total condemned organs due to bTB was estimated at ₦7,636,800.00 ($18,626.34). The average loss from condemned lungs per annum was ₦ 4,132,800 ($10,080). It was established that bTB was responsible for significant economic losses due to the condemned organs of slaughtered cattle at the Gombe township abattoir.

Keywords: Abattoir, Bovine Tuberculosis, Economic losses, Gombe, Northeast-Nigeria

INTRODUCTION

Bovine tuberculosis (bTB) caused by *Mycobacterium bovis* is a contagious chronic disease with fatal effects on both-human and animals (Radostits *et al*., 2010). It equally affects wildlife and several mammalian species (O'Reilly and Daborn, 1995). However, cattle have been incriminated as the primary host of the disease where it serves as a reservoir (Thoen *et al.*, 2006; Radostits *et al.*, 2010). It is easily identified at post-mortem by the presence of granulomas in tissues such as lungs, kidney, intestine, liver, spleen, heart and lymph nodes (Corner, 1994; FAO, 1994; Grist, 2008). Human Tuberculosis is a serious health threat in most developing countries, including Nigeria and was associated with malnutrition, poverty, failed health care system, and rapid increase in human population (Ankrah, 1995). The disease has been endemic in Nigeria (Alhaji, 1976), and has been incriminated as the leading cause of death from a single infectious agent in Nigeria and it also has a global distribution particularly in most developing countries (Můller *et al*., 2013; WHO, 2018). Tuberculosis is a public health threat with 8-9 million new-cases and mortality of 3 million annually worldwide, mostly in underdeveloped countries (WHO, 2013).

In developing countries such as Nigeria, nomadic pastoralism predisposes the livestock to bTB as a result of stress, overcrowding, malnutrition and increased contact with infected livestock (Ejeh *et al*., 2017; Sa'idu *et al*., 2017; Mohammed *et al*., 2019). Bovine tuberculosis is a bacterial disease with zoonotic and economic implications resulting in losses of human life, a significant amount of money from the condemnation of carcasses at slaughter, restriction of international trade, decrease of productive time on the part of farmers (Acha and Szyfres, 2003; Zinsstag *et al*., 2006; Cadmus and Adesokan 2009, OIE, 2009). However, the diagnosis of this disease at the abattoir was based on detection of gross lesions at postmortem (Alhaji, 1976; Saidu *et al.*, 2017; Cadmus *et al.*, 2019). Abattoir meat inspection may play a great role as diagnostic, preventive and surveillance tool in most of our local abattoirs. Apart from the provision of epidemiological data on life-threatening zoonotic diseases of meat-borne origin, such as bovine tuberculosis, it also provides standard procedures for meat processing, ensures hygiene, wholesome meat-free from infections and other drugs residues, (including heavy metals and chemicals used in Nigerian abattoirs/meat processing industries). Abattoir based studies have established reliable data on bTB over a decade in Africa as reported by Corner (1994), Adamu (2014), Adu-Bobi *et al.* (2009) and Aliyu *et*

al. (2009). However, there is no active national bovine tuberculosis surveillance and economic losses at the herd and farm level in Nigeria. Therefore, this study was aimed at determining a ten-year (2008-2017) annual and seasonal prevalence rates of bTB and to estimate the economic losses associated with the condemnation of the organs affected with bTB lesions in GTA, Gombe, Nigeria.

Materials and Methods

Ethical Statement

The approval and consent of the government was formally received through the head of the abattoir prior to the commencement of the study.

Study Area

The study was conducted in Gombe abattoir which lies between the latitude 10.17°N and longitude 11.11°E in Gombe town, Gombe State, Nigeria. The wet season is from April to October and the dry season is from November to March. Gombe has a population of 266,884 and10-year projected population of 367,500 with per capita income of ₦424,760 ($1,036) (Census, 2006).

Study Design

A retrospective study of bTB cases recorded in the Gombe Modern Township Abattoir was carried out. Records were obtained from the Veterinary record book at Gombe Area Veterinary Office and Gombe Township Abattoir. Records of slaughtered cattle examined at postmortem and found with typical tubercle lesions at the abattoir from 2008 to 2017 as described by Corner (1994) and Grist (2008) were considered in this study.

Routine Post-mortem Procedure

For this study, cattle brought in for slaughter were subjected to antemortem inspection and slaughter was by Halal method. Postmortem (PM) examination was conducted by Veterinarians. The meat inspection procedures employed visual examination and palpation of the lungs, liver, kidneys, lymph nodes of the carcass including the mesenteric lymph nodes, intestinesand detection of typical tubercle, yellowish granulomatous caseated lesions and sometimes 'gritty' calcification in the organs (FAO, 1994; Corner, 1994; Grist, 2008).

Determination of Prevalence

The monthly prevalence rate of the disease was calculated as the total number of cases of bTB detected in a month divided by the total number of cattle slaughtered that month, while the annual prevalence rate was calculated as the total number of bTB detected in a year divided by the total number of cattle slaughtered that year and expressed in percentage (Biermans *et al.*, 2008). The overall prevalence rate was calculated as the total number of cases detected over the total years under investigation divided by the total number of cattle slaughtered for all the years and presented in percentage reference. The seasonal prevalence rate was also determined by calculating the number of cases recorded during the rainy season (April-early-October) and the dry season period (November-March) and presented in percentage (Radostits *et al.,* 2007).

Estimation of Economic Losses

The average cost per kilogram of visceral organs affected by bTB was obtained through the standard market price from the butchers as at the time of this study and compared with the FAO-global standard price for meat and meat products per kg. Weighing scale (citizen® electronic weighing balance with 0.1g-100 kg precision) was used to determine the average weight of visceral organs. The average weight of lungs (1.6 kg), liver (3.5 kg), spleen (0.8 kg), heart (1.7 kg), intestine (8.5 kg) and kidneys (1.5 kg) were determined using a weighing scale. The average cost per kilogram of organs affected was estimated at ₦1500 ($3.66). The number of condemned meat (unfit) for human consumption among slaughtered cattle at GTA was determined.

Statistical Analyses

Data were entered into the Microsoft Excel (Version 2019 for Windows 10) and imported into SPSS^R statistical software (Version 20 for Windows^R, S PSS Inc., Chicago, USA) for further statistical analyses. Chi squared (χ^2) test of association was calculated, and OR was determined to assess the strength of association and only those variables with a ($P < 0.05$) were considered significant. Further, descriptive statistics were carried out and results were presented in form of tables and chart using Microsoft Excel (Version 2019 for Windows^R 10).

RESULTS AND DISCUSSION

Annual prevalence of bTB for a period of 10 years (2008-2017) revealed an overall prevalence of 0.96%. In 2011 alone, 23,139(12.90%) cattle were slaughtered with a lower prevalence of 0.34%, while in2017, a total of 9643 cattle was slaughtered representing (5.40%) cases was recorded, the highest prevalence of 3.60%. There was a statistically significant association ($\chi^2 = 8.14$, $p<0.05$) between the prevalence of bTB and its annual occurrence for the period under study. Regarding the seasonal variation, wet season with a total of 106, 033 (59.30%) slaughtered cattle within the period of the study had the highest prevalence of 1120 (1.06%). Whereas, in the dry season 72, 814 (30.70%) slaughtered cattle were recorded representing the lowest prevalence of 602 (0.83%). Furthermore, there was a statistically significant association ($\chi^2=23.42$, $p<0.05$) between the prevalence of bTB and season (Table 1). This also reflects the temporal patterns of bTB in GTA.

Secondly, the total condemnation of the lungs due to bTB in slaughtered cattle during post-mortem was estimated at 1,722 organs. The resultant economic losses due to the lungs weighing 2,755.20kg worth ₦4,132,800 ($10,080) were condemned. Similarly, in 2015 alone, a total of 209 (12.10%) lungs weighing 334.4kg and valued ₦ 501,600($1,223.41) were condemned. However, in 2017 the highest recorded 347 (20.20%) number of loss due to lungs, weighing 555. 20kg worth about ₦ 832,800 ($2,031.22) were condemned, while in 2011 which had the lowest number 78 (4.50%) of condemned lungs, weighing 124.8kg worth of ₦187,200 ($456.60). The results are presented in (Table 2). The economic losses from condemnation of different edible

organs affected with bTB lesions in cattle slaughtered at Gombe township abattoir over a period of 10 years are presented in (Table 3).

The temporal trend of the disease has been traced to be more in rainy season than in dry season. Furthermore, there was a statistically significant association (χ^2=23.42, p<0.05) between the prevalence of bTB and season in GTA. The prevalence rate was higher in August-September but decreases in October through December. The disease incidence then slightly increased from January-April, whereas a sharp decrease was noticed in May with a little bit increase in June and a gradual decrease in July. This is an intermittent incidence of bTB due to seasonal influence and the period between April and September marks the rainy season in the study area (Figure 1).

Table 1: Annual and seasonal prevalence of bovine tuberculosis (bTB) lesions in cattle slaughtered at Gombe township abattoir over a period of ten years (2008-2017)

Variables	Slaughter Figure	TB Lesions	Prevalence (%)	χ^2	P-value
Year					
2008	17090	130	0.76	8.14	0.0001*
2009	19161	185	0.97		
2010	17465	163	0.93		
2011	23139	78	0.34**		
2012	16306	150	0.92		
2013	22337	170	0.76		
2014	18951	117	0.62		
2015	20113	209	1.04		
2016	14642	173	1.18		
2017	9643	347	3.60**		
Season					
Wet season	106033	1120	1.06	23.40	0.0001*
Dry season	72814	602	0.83		
Total	178847	1722	0.96		

* P < 0.05 = statistically significant, ** significant extreme values.

Table 2: Annual and seasonal economic losses from condemnation of edible lungs affected with bovine tuberculosis (bTB) lesions in cattle slaughtered at Gombe township abattoir over a period of ten years (2008-2017)

Variables	Number of affected lungs with TB Lesions (%)	Weight (Kg)	Naira (₦)	Dollar ($)
Year				
2008	130(7.5)	208.00	312000	760.98
2009	185(10.7)	296.00	444000	1082.90
2010	163(9.5)	260.80	391200	954.15
2011	78(4.5)	124.80	187200	456.60
2012	150(8.7)	240.00	360000	878.05
2013	170(9.8)	272.00	480000	995.12
2014	117(6.8)	187.20	280800	684.88
2015	209(12.1)	334.40	501600	1223.41
2016	173(10.0)	276.80	415200	1012.68
2017	347(20.2)	555.20	832800	2031.22
Total	1722			
Season				
Wet	1120	1792.00	2688000	6556.10
Dry	602	963.20	1444800	3523.90
Total	1722	2755.20	4132800	10080

*₦=Naira, $:US Dollars, Kg: kilogram Conversion rate = $: ₦410

Table 3: Economic losses from condemnation of different edible organs affected with bovine tuberculosis (bTB) lesions in cattle slaughtered at Gombe township abattoir over a period of ten years (2008-2017)

Organs	Number of affected organs with TB Lesions (%)	Weight (Kg)	Naira (₦)	Dollar ($)
Lungs	1722 (67.0%)	2755.2	4132800	10080
Heart	133(5.2%)	226.1	339150	827.20
Spleen	163(6.3%)	130.4	196350	478.90
Liver	94(3.7%)	329	493500	1203.66
Intestine	138(5.4%)	1173	1759500	4291.46
Kidney	318(12.4%)	477	715500	1745.12
Total	2568	4613.7	7636800.00	18626.34

*N= Naira, $=US Dollars, Kg= kilogram

Table 4: Direct Estimates of Economic Losses due to Bovine Tuberculosis Condemnation at Gombe Township Abattoir, Gombe State

S/No.	Parameters	Quantity/Price (N)
1	Number of slaughtered cattle	178847
2	Total Number of condemned organs	2568
3	Total Number of Condemned lungs	*1722 (20 lesions each)
4	Total Number of Tubercle lesions in the lungs	34440
5	Percentage prevalence	0.96
6	The average cost of meat/kg	₦ 1500($3.66)
7	Loss/infected animal	₦1440 ($4.0)
8	The average number of meat loss/annum	275.52 kg
9	Meat loss due to bTB/annum	₦ 7,636,800 ($18, 626.34)
10	The average cost of Adult cattle	₦ 400, 000($975.61)

*₦ = Naira, Kg= kilogram, *Average number of tubercle lesions per lung

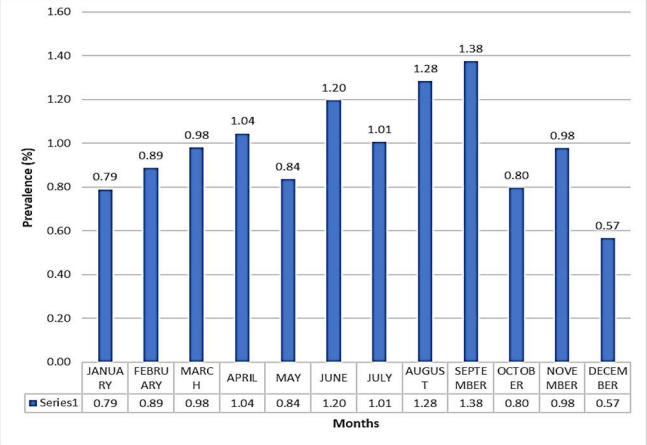

Figure 1: Monthly prevalence of bovine tuberculosis (bTB) lesions in cattle slaughtered in Gombe township abattoir over a period of ten years (2008-2017).

The Losses due to condemned organs, and other direct losses were considered based on the total number of affected organs (n=2568). The total economic losses due to the disease were estimated at ₦4, 132,800($10,080) and for single cattle was ₦2,400.00($5.85). The figures and parameters used are presented in (Table 4).

The overall (2008-2017) prevalence rates of 0.96% obtained in the present study for bTB was slightly higher compared to the recent study by Saidu *et al.* (2017) in the same area, who recorded a prevalence rate of 0.76% of bTB over a period of 8 years, but the differences might be attributed to the increased slaughter capacity in the additional years of the study, as previously reported by Awah-Ndukum *et al*. (2010). However, the prevalence established in this study was lower than the previous studies conducted in the same study area by (Aliyu *et al*., 2009; Madaki et al., 2012; Adang *et al.*, 2015; Ibrahim *et al.,* 2018). Aliyu *et al*. (2009) and Abubakar *et al*. (2011) in their previous retrospective studies recorded a relatively higher prevalence of 12.27% in Gombe State when compared to the findings in the current study. This might be attributed to improved awareness and herd health management practices among the pastoralist communities within the state as documented by Sa'idu *et al*. (2015). The total prevalence of 0.96% bTB among the slaughtered cattle examined at PM during meat inspection had revealed the crucial role of these tools in detecting and minimizing some food-borne zoonotic diseases of public health and economic significance such as bTB, brucellosis, parasitic infections, among others (Cosivi *et al.*, 1998; Aliyu *et al.* 2009; Sa'idu *et al.* (2015) reported that bTB has been an endemic threat in the study area and Nigeria at large. This agrees with the earlier reports by Cadmus *et al.* (1994), as post-mortem examination remains the immediate, cheap, and rapid diagnostic tool to be used in endemic slaughterhouses and abattoirs in most states of Nigeria. However, the recorded bTB prevalence rate in Gombe abattoir might have established an estimated baseline figure of the true prevalence rate of the disease, most likely due to missing data, scarcity of vital information, butchers' compliance and lack of animal disease monitoring and surveillance (reporting network).

The results indicated the highest prevalence rate of 3.6% of bTB in 2017 as compared to the previous years. This might be due to discontinuity in public health measures due to violent conflict between nomadic herdsmen and indigenous farmers around north-central States; Benue, Nasarawa and Plateau, a large 92, 089 Km^2 geographic area with abundant greener pasture for animal grazing. The unrest has also contributed to the restriction in the movement of the cattle/herdsmen/nomads which gave a favorable condition for the spread of bTB among cattle due to increase contacts, overcrowdings of animals and malnutrition as potential risk factors of the disease. The limitation of this current study is that, significant number of the slaughtered animals could not be traced as most cattle might have been sourced from pastoralists which are difficult to trace back. This is due to the nomadic system of animal husbandry and livestock trade. The reason for the lower prevalence rate of 0.34% in 2011 found in the present study might be attributed to the sources of the animals and the limited access to the former source (Maiduguri axis) of animals for slaughter and majority of the animals were from Adamawa and Cameroon border that might have less prevalence rate of the disease as reported earlier by Aliyu *et al*. (2009).

The disease has a seasonal trend as a risk factor that also influenced the occurrence of the disease in the study area. This finding is in accord with the study presented by (Pollock and Neill, 2002; Kudi *et al*., 2012). This resemblance coincided with the seasonal movement of nomadic herdsmen in search for greener pasture by moving their cattle from the southern part of the country to the north during the rainy season, this clearly explained the myths and proclamation that there would be a likelihood that these cattle might have incubated the infection before coming back to the north as reported by Awah-Ndukum *et al.* (2010). The low prevalence rate reported in the current study may be due to underestimation of tubercle lesions during PM meat inspection in slaughtered cattle and probably might be associated with a lack of expertise at PM. Furthermore, inadequate facilities and lack of compliance among butchers is another reason. The AM and PM inspections of food animals slaughtered for human consumption in an abattoir required expertise, facilities in place, and extra financial budget for compensation of condemned organs to ensure safe and wholesome meat to the general public. Therefore, to reduce excess economic losses in a resource-challenged nation like Nigeria, there is a need to set up a standard operational procedure for postmortem inspection of slaughtered animals for human consumption as documented by EFSA (2003). For instance, developed countries have well-developed procedure and documented criteria for the condemnation of organs/carcass unfit for human consumption. For example, small ruminants with more than twenty cysts would be condemned and meat from animals diagnosed with miliary tuberculosis is considered unfit for human consumption as reported by Awah-Ndukum *et al.* (2010). This is contrary in the developing countries like Nigeria as reported by Ibrahim *et al.* (2018) because of the peculiar economic situation only the affected organ(s) or part of the carcass would be declared unfit for human consumption instead of total condemnation.

The current study revealed a total of 2,568 condemned edible organs weighed 4,613.70kg and valued at four million five hundred and eighty-one thousand six hundred and thirty Naira (₦7,636,800) equivalent to Eighteen thousand six hundred and twenty-six US Dollar and thirty-four cent ($18, 626. 34), as a result of condemnation of organs affected by tubercle lesions during PM. The high economic losses due to condemnation of edible organs valued at a significant amount of money as indicated above without any compensation to butchers. This might be a hindrance behind the lack of butchers' compliance to whole carcass condemnation and only partial condemnation of the affected parts was allowed to be carried out with a serious public health implication and huge Daily Adjusted life years (DALYs). This is contrary to what was practiced in developed countries, and also might be the reason for unfriendly attitude of butchers toward meat inspectors at most abattoirs in Nigeria and other developing Southeast Asian countries and Sub-Saharan Africa as documented by O'Reilly and Daborn, (1995). Cadmus *et al*. (2009) and Ibironke and Fasina, (2010) reported that bTB contributes toward the economic suffering of our people; this is because some farmers and traders depend entirely on the profits from sales of cattle offal as their source of livelihood. This is similar to the finding of the current study and might be a reason for lack of butchers' compliance to the whole carcass condemnation and unfriendly attitude toward meat inspectors in which only partial condemnations of affected parts were allowed to be carried out, after which the remaining unaffected (invisible) parts were passed for human consumption.

In the present study, our observations revealed that there was no standard scheme for compensation of condemned edible organs. This may deprive teaming butchers and farmers of their source of livelihood. Hence, this might bring about psychological depression, frustrations and social vices such as the banditry and cattle wrestling in the livestock-rich/pastoralist northern parts of Nigeria and also contributed to an alternative increase in their cost price to compensate for the condemned part, which might deprive those with low income in our community from accessing these rich nutrients. This agrees with the findings by Blench, (1999) and Ejeh *et al*. (2014). Edible organs condemned include lung, kidney, spleen, intestine, and heart. These organs are rich sources of minerals, vitamins, amino acids, and other nutrients which is why sometimes prescribed by health personnel for pregnant women, malnourished children and individuals suffering from other mal-nutritional health conditions.

Lungs recorded the highest 1722 (67.00%) number of condemned organs than others; this agrees with the results by Rohnoczy *et al.* (1996) and Raja, (2004) who observed that gross lesions of tuberculosis were most often in the lung tissue, these may be due to its richness in oxygen supply. Thus, serves as a predilection site for *Mycobacterium* species, being obligatory aerobic, intracellular pathogens. There was a significant difference in economic losses from the condemned liver and other edible organs. This is because the liver is heavier than other condemned organs and the price is directly proportional to the weight of the organ. It is also very expensive due to the high demand associated with its high nutrient contents coupled with customer acceptability.

Conclusion

The study revealed a total prevalence of bTB at 0.96% over a period of 10 years with a resultant total economic loss of ₦7, 636, 800 ($18, 626.34) due to the condemnation of affected organs at PM in GTA. The total losses due to condemnation of lungs alone was estimated at ₦4,132,800 ($10,080). The disease has a seasonal trend with highest (1.06%) prevalence in wet season with an economic loss of ₦2,688,000 ($6,556.10) as a result of lungs condemnation. The study also revealed significant association (p=0.0001) between year, season and occurrence of bTB. We recommend the enforcement and implementation of the condemnation policy with a compensation scheme at the GTA abattoir. Animal disease monitoring and surveillance program should be encouraged among the stakeholders to safeguard the public and animal health.

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Conflict of Interest

The authors declare that they have no conflict of interest.

Authors Contribution

SM and ASS designed the study, did the data collection, and SM, US and ASS wrote the first draft of the manuscript. GSA, and AOT supervised the whole research and reviewed the manuscript. SM, ASS and US contributed to the data collation, cleaning and managed the data analyses of the study. US, did the literature searches as well. All authors read and approved the final manuscript.

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