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SEASONAL PREVALENCE OF BOVINE TUBERCULOUS LESIONS IN CATTLE SLAUGHTERED IN YOLA ABATTOIRS

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ABSTRACT

Bovine tuberculosis is endemic in Nigeria. There is paucity of information on the prevalence of bovine tuberculous lesions in cattle slaughtered in Yola, Adamawa state. The annual prevalence and seasonal variation of bovine tuberculous lesions were assessed based on abattoir records of tuberculosis lesions from 2008 to 2012. The overall prevalence of bovine tuberculosis lesions from 2008 to 2012 ranges from 8.68% (6.03 – 11.33) in 2008 to 10.33% (8.63 – 12.03%) in 2012 with peak prevalence of 12.73% in 2011. Types of lesions were not recorded systematically, however, lesions that were observed ranges from TB granuloma, TB abscesses with yellowish pus, caseous necrotic tubercles, multiple necrosis to focal granulomas. Annual prevalence of bovine tuberculosis lesions recorded in Yola abattoirs differ significantly ($p \leq 0.05$). Prevalence of tuberculous lesions in Yola abattoirs was significantly influenced by season ($p < 0.05$). Tuberculosis is endemic in cattle slaughtered in abattoirs meant for human consumption in Yola, therefore humans are at risk of acquiring zoonotic tuberculosis through consumption of contaminated meat.

Key words: Bovine tuberculosis, tuberculous lesions, Yola, prevalence, zoonotic

INTRODUCTION

Bovine tuberculosis (TB) is characterized by the development of granulomas (tubercles) where bacteria have localized. The granulomas are usually yellowish and either caseous, caseo-calcareous or calcified and often encapsulated (Rohonczy *et al*., 1996). Gross lesion were more in the thoracic cavity than in other regions of the body, the mediastinal lymph nodes are most commonly affected in TB confirmed animals while the tonsils are least affected (Liebana *et al.,* 2008). In the lungs, the lesions are multiple coalescing foci of caseous necrosis surrounded by thin pale fibrous tissue capsule (tubercles) (Liebana *et al.,* 2008). The lung parenchyma is almost entirely replaced by variably sized, coalescing, raised, pale nodules. Most of the lymph nodes are replaced by caseonecrotic debris with a laminated appearance reminiscent of caseous lymphadenitis (Rohonczy *et al*., 1996), in pigs the center of the lynph nodes is replaced by caseous, mineralized debris (Kaneene and Thoen, 2004), while the liver look pale and slightly raised granulomas are disseminated throughout all liver lobes (Anonymous, 2009). In bovine uterus, the endometrium contains numerous raised tubercles; the organism is also responsible for endometritis in women (Kumar *et al*., 2008). In some species such as deer, the lesions resemble abscesses rather than typical granuloma. Some tubercles are so microscopic that they cannot be seen with the necked eyes except with the aid of microscope in a sectioned tissue (Anonymous, 2009). Bovine tuberculosis is a disease caused mostly by the bacterium *Mycobacterium bovis* (Smith *et al.,* 2006), *Mycobacteriumcapriae* (Brosch *et al.,* 2002), *Mycobacterium tuberculosis* has been reported as the cause of tuberculosis in cattle (Cadmus *et al.,* 2006) as well as other members of the MTbC (Cadmus *et al*., 2010; Jenkins *et al*., 2011). *Mycobacterium bovis* (*M. bovis*) can be transmitted by inhalation of aerosol, by ingestion or through break in the skin. The important of the routes varies between species (Anonymous, 2009). Venereal transmission through artificial insemination (AI) is possible (Wentink *et al*., 2000). Aerosol transmission occur usually where animals are in closed contact, thus animal density play a major factor in the transmission of *M. bovis* (Anonymous, 2013). Bovine tuberculosis is usually maintained in cattle populations (Anonymous, 2009), a few others can become reservoirs. Transmission of tuberculosis from cattle to human mostly occur through consumption of unpasteurized milk, closed contact with infected animal (Michel *et al*., 2010), air borne transmission (Vekemans *et al.,* 1999; WHO, 2009) and consumption of infected meat (Anonymous, 2009). Tuberculosis in cattle is a disease of economic and zoonotic importance.

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The disease is distributed worldwide, with African and Asian countries ranking highest in terms of disease burden (WHO, 2009). In developed countries, bovine tuberculosis had been controlled through test and slaughter method (Cosivi *et al.,* 1998; Ayele *et al.,* 2004; Theon *et al.,* 2006; Amanfu *et al.,* 2006; Smith *et al*., 2006), although bovine tuberculosis is still endemic in some industrialized countries like Australia and the Caribbean Island (Tweddle and Livingstone, 1994). The situation of bovine tuberculosis is completely different in Africa; with the emergence of HIV/AIDS, poverty and other debilitating diseases. The prevalence of bovine tuberculosis continue to increase in animals, these situation have potential impact on human health directly and threat to human livelihood by compromising sustainable food supply, income and social status (WHO, 2006).

Abattoir meat inspection provides useful insight into the prevalence of many animal diseases (FAO 1994; Cassidy *et al.,* 2008) including TB, although by their nature, abattoirs' records are limited in detail in the data they provide (Aliyu *et al.,* 2009), their importance cannot be over emphasized. In Nigeria, most of the studies were based on gross pathological examination at the abattoir (Igbokwe *et al.,* 2001; Ameen *et al.,* 2008; Aliyu *et al.,* 2009; Ibironke and Fasina, 2010; Kwaghe *et al.,* 2011) due to poor research infrastructure, funding and man power. There is paucity of information on bovine tuberculosis in Yola, Adamawa State, this study is therefore aimed at providing baseline information on the prevalence and seasonal variation of gross pathological lesions associated with bovine tuberculosis in cattle slaughtered in abattoirs in Yola, Adamawa State, Nigeria.

MATERIALS AND METHODS

Adamawa State is located at the North Eastern part of Nigeria (Figure 1). It lies between latitude 7 and 110° N and between Longitude 11 and 140° E. It shares boundary with Taraba State in the south and west, Gombe State in its North-west and Borno State to the North. The State has an international boundary with the Cameroon Republic along its eastern side. It has a land area of about 38,741 km^2 (Adebayo, 1999). The State is divided into 21 local government areas. Adamawa State has a tropical wet and dry climate. Dry season lasts for a minimum of five months (November- March) while the wet season spans April to October. Mean annual rainfall in the State ranges from 700 mm in the Northwest, to 1600 mm in the extreme southern part of the State (Adebayo, 1999). The State has low humidity and high temperature. The climate is also characterized by high evapo-transpiration especially during the dry season (Adebayo, 1999). Yola, the State capital being an urban centre has an estimated population of about 200,000 people.

Data collection

Abattoir data were collected, after a formal permission obtained from relevant authority at the Ministry of Agriculture and Natural Resources (MANR) Yola, Adamawa state.

Meat inspections at abattoirs in Yola were carried out by qualified veterinarians who served as meat inspectors. Data collected include; number of cattle slaughtered monthly, number of cattle slaughtered that exhibit gross pathological lesions typical of bovine tuberculosis and their sex. These data were collected for a period of five (5) years (2008 – 2012). Post mortem examination of the carcass was done by meticulous visual examination, careful palpation and incision of the lungs, kidney, liver, lymph nodes, spleen, heart, and other part of the tissues/ organs of the body for condemnation. Affected parts are usually trimmed and the rest passed for consumption while generalized cases of bovine tuberculosis are usually seized and destroyed by the veterinarians (FAO, 1993). No pre slaughter test or ante mortem examination was carried out before slaughter.

Data analysis

Prevalence was calculated as the number of cattle with suspected bovine tuberculosis lesions divided by the number of cattle examined at post mortem within the specified period (Aliyu *et al.,* 2009). Data obtained were further subjected to student t-test and ANOVA for the establishment of significance using SPSS version 16.

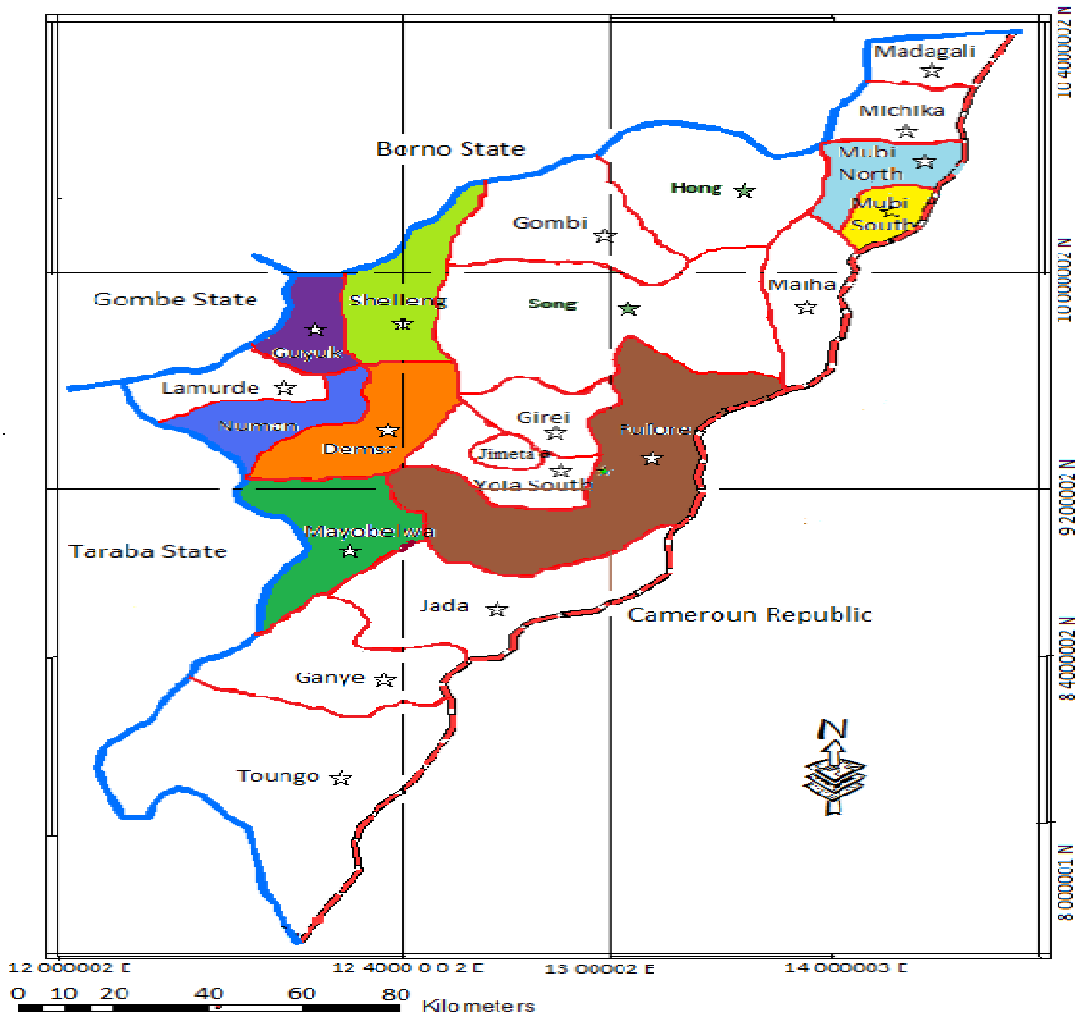

Figure 1: Map of Adamawa State showing Yola

RESULTS

Annual distribution

Table 1 show meat inspection data for the number of slaughtered cattle and bovine tuberculosis lesions detection for a period of five years (January 2008 to December 2012). In 2008 a total of 16753 (22.62%) cattle were slaughtered, similar figure were slaughtered in 2009 but from 2010 to 2012 the number of cattle slaughtered in the abattoirs decreases drastically to 13152 (17.75%), there was a significant difference between the number of cattle slaughtered from 2008, 20009 and 2011 and from 2010 and 2012 ($p > 0.05$). Annual distribution of detection of tuberculosis lesions in cattle slaughtered in Yola show that the highest prevalence of TB lesions were detected in 2011 with a mean detection of 12.73% (95% CI: 8.2184 - 17.2499%) and is significantly different from the mean detection recorded in 2008 (8.68%) 2009 (7.30%) and 2010 (4.40%) ($p < 0.05$). An overall mean detection of 8.78% (95% CI: 7.5698 - 9.9852%) was recorded for the period of five years (Table 1 and Figure 2).

Sasonal variation

A total of 74079 cattle were slaughtered at the Yola abattoir from 2008 to 2012, during the late raining season more cattle were slaughtered 26170 (35.33%) than other season, although this figure is not significantly different compare to total number slaughtered during other seasons.

While total number of cattle slaughtered 11640 (12.71%) during the late dry season is lower compare to other seasons, also they were not different statistically ($p > 0.05$). The prevalence of tuberculous lesions among cattle slaughtered in Yola from early raining season to late dry season ranges from 10.62% (95% CI: 8.06 - 13.18) to 12.71% (95% CI: 7.70 - 17.73). Prevalence of tuberculous lesions recorded during the late dry season (12.71%) is higher compare to other seasons and is significantly different from the prevalence of tuberculous lesions recorded during the late raining season and early dry season ($P < 0.05$). The lowest prevalence was recorded during the late raining season 6.98% (95% CI: 5.46 - 8.50%) and early dry season 6.71% (95% CI: 5.71 - 7.71%).

Table 1. Number of cattle slaughtered and prevalence of bovine tuberculous lesions detected in Yola abattoirs from 2008 – 2012

Year	No. Slaughtered (%)	No. with TB lesions	Prevalence % (95% CI)
2008	16753 (22.62)^{a}	1303	7.7^{c} (7.4 - 8.2)
2009	16394 (22.13)^{a}	1147	6.9^{c} (6.6 - 7.4)
2010	13590 (18.35)^{b}	671	4.9^{d} (4.6 - 5.3)
2011	14290 (19.29)^{a}	2088	14.6^{e} (14.0 - 15.2)
2012	13152 (17.75)^{b}	1403	10.7^{g} (10.1 - 11.2)
Season			
Early Rain	18235 (24.62)	1997	10.9^{a} (10.5- 11.4)
Late Rain	26170 (35.33)	1931	7.4^{b} (7.1 - 7.7)
Early Dry	18033 (24.34)	1242	6.9^{b} (6.5 - 7.3)
Late Dry	11640 (12.71)	1422	12.2^{c} (11.6- 12.8)
Sex			
Male	29629 (40.00)^{c}	2205	7.4^{a} (7.1 - 7.7)
Female	44450 (60.00)^{d}	4407	9.9^{b} (9.6 - 10.2)
Total	74079 (100.00)	6612	8.9 (8.7 - 9.1)

Mean percentages with the different letter(s) in the same column were different significantly ($p > 0.05$)

Sexual distribution

The sexual distribution of bovine tuberculous lesions in cattle slaughtered in Yola from 2008 to 2012 is presented in Table 1. More female cattle were slaughtered 44450 (60.0%) than male cattle, there was statistical significant difference between male and female cattle slaughtered in Yola, Adamawa state ($p < 0.05$). Also the prevalence of tuberculous lesion in female cattle slaughtered in Yola (10.99%(-5.62422 - 0.90845%) is significantly different from the prevalence of tuberculous lesions recorded in male cattle slaughtered in abattoirs in Yola ($p < 0.05$).

Monthly pattern of distribution of bovine tuberculosis.

The prevalence was high from January, during the late dry season and then increases from February and peaks in March which coincided with the driest and hottest month in Yola, it then drop in April.

The prevalence of tuberculous lesions gradually peaks again in June and August and decreases more gradually from August to December (Figure 2).

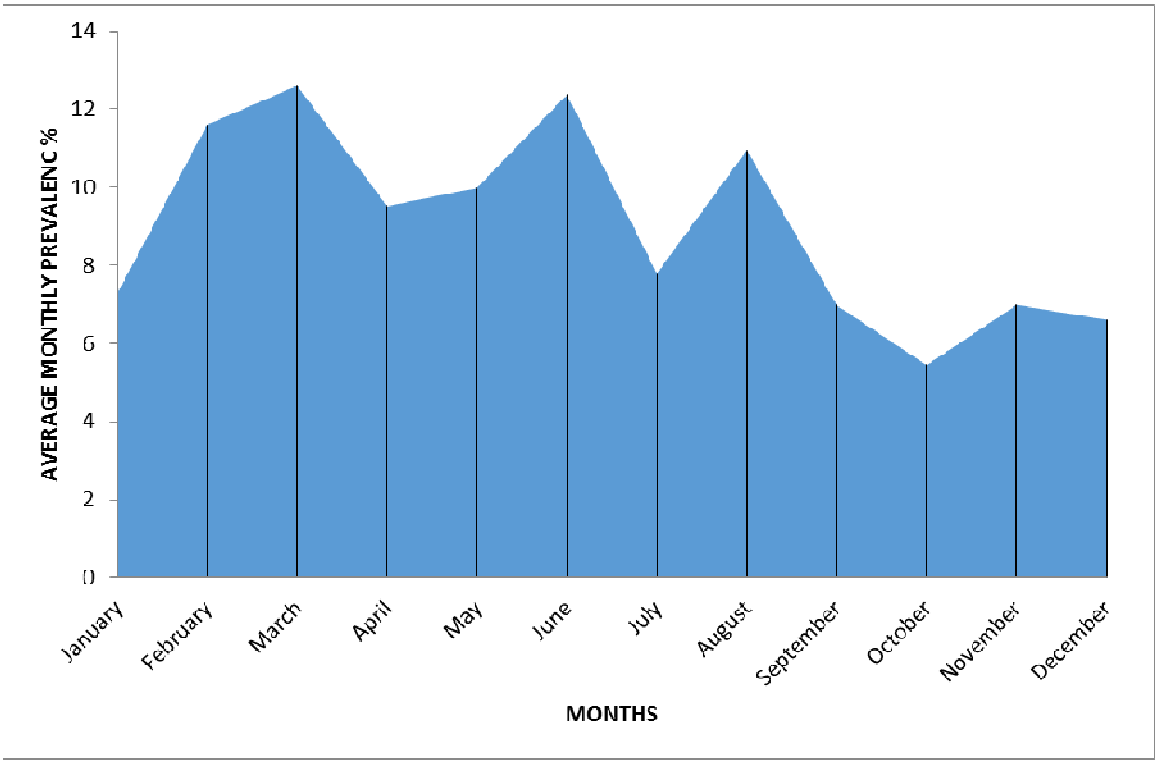

Figure 2: Show the pattern of distribution of the average monthly prevalence of tuberculous lesions in cattle slaughtered in abattoirs in Yola.

DISCUSSION

The uses of secondary data to determine the prevalence of bovine tuberculosis is not a novel finding per se but it provide information in the overall context of disease surveillance and monitoring (Cassidy *et al.,* 2008; Aliyu *et al.,* 2009). In developing countries especially Nigeria where laboratory investigations are not been carried out at the abattoirs due to lack of laboratory infrastructures and implementation of Government policy, abattoir meat inspection for pathological lesions remain the best option for monitoring bovine tuberculosis and other important disease prevalence (Aliyu *et al.,* 2009). The annual prevalence of tuberculous lesions in cattle slaughtered at the Yola abattoirs from 2008 to 2012 range from 8.68% (– 11.33%) in 2008 to 10.33% (6.63 – 12.03%) in 2012 with an overall annual prevalence of bovine tuberculosis lesions of 8.78% (7.57 – 9.99%). Similar prevalence (8.30%) was reported by Cadmus *et al.,* (2003) in food Animals in Nigeria. These findings are higher than earlier reports of bovine tuberculosis in the area. In Adamawa a prevalence of 0.34% was reported by Aliyu *et al.,* (2009) and other parts of Nigeria such as Ogbomoso, 0.55% (Ameen *et al.,* 2008), 1.4% in Enugu (Nwata *et al.,* 2011) except in Gombe State where the prevalence of bovine tubercululous lesions recorded in abattoirs was 12.27% (Aliyu *et al.,* 2009). Researchers in other parts of African countries reported similar findings. In Chad a prevalence of about 9% bovine TB was reported in slaughtered cattle (Milan *et al.,* 2000), and 6% prevalence in Cameron (Theon, 2009).

The reason for the high prevalence of tuberculous lesions in cattle slaughtered in Yola abattoirs is not clear but may be due to the fact that there is no active bovine tuberculosis control program in Nigeria and that movement of cattle across both local and international boundaries, this situation may promote the entrance of infected animals from neighboring countries such as Chad, Republic of Niger and Cameron (Aliyu *et al.,* 2009), another explanation for the high prevalence of tuberculous lesions in cattle slaughtered in Yola abattoirs could be due to absence of pre- slaughter examination and or test to separate cattle that are fit for slaughter from those that are not fit for slaughter. Season play significant role in the detection of bovine tuberculous lesions in cattle slaughtered in Yola abattoirs.

During the late dry season and early raining season, prevalence of tuberculous lesions were 12.71% and 10.62% while the prevalence was lower during late rainy season (6.98%) and early dry season (6.71%) respectively. This findings differ from the report of Awah – Ndukum *et al*. (2010) in Cameron who reported that the detection of TB lesions was not influenced by season but was high during stressful periods such as inter season and peak – season periods. Also Ameen *et al*. (2008) reported similar finding in Oshogbo, Nigeria. Nwata *et al*. (2011) reported a prevalence of 13.2% during the rainy season and 12.5% during the dry season, which showed that variation in seasonal prevalence was not significant. Although these researchers do not consider the influence of various stages of the seasons such as early and late season on tuberculosis lesions detection. However, Bikom and Oboegbulem (2007) reported a strong association between tuberculous lesions and seasonal distribution. In a similar study in Egypt, Ahmed *et al*. (2013) reported significant difference between season and pathological finding in cattle slaughtered in Ismailia abattoir. The reason for the difference in seasonal variation and tuberculous detection observed in this study is yet unknown. There was strong association between sex and tuberculous lesions detected in cattle slaughtered in Yola abattoirs. These findings agree with that of Nwata *et al*. (2011) and Awah – Ndukum *et al*. (2010). Ameen *et al*. (2008) reported that there was no strong association between sex and tuberculous lesions detected in slaughtered cattle. Female cattle stay longer in the herd than male cattle for breeding purpose making them more exposed to *Mycobacterium* spp. (Milan *et al*., 2000; Ita *et al*., 2005; Nwata *et al.,* 2011).

CONCLUSION

The result of this study indicates that bovine tuberculosis is endemic in cattle slaughtered in Yola abattoirs meant for human consumption, therefore human are at risk of acquiring tuberculosis through consumption of contaminated meat. Further studies should be carried out to investigate the species of *Mycobacterium* responsible for the lesions recorded in abattoirs in Yola. Study is also needed in humans who are at risk of zoonotic tuberculosis especially immunocompromised individuals, livestock rarer, abattoir workers, meat vendors and animal health professionals to determine the epidemiology of zoonotic tuberculosis. There is need for veterinarians to intensify effort to educate those who are involved in the meat industry on the danger of zoonoses especially tuberculosis.

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REFERENCES

1. Adebayo AA (1999). Climate I: Sunshine,Temperature, Evaporation and Relative humidity in Adebayo, A. A. & Tukur, A. L. (Eds) *Adamawa State In Maps.*Geography Department, Fedearal University of Technology, YoIa. *Paraclette Publishers*, *Yola*. Pp 20-22.
2. Ahmed AM, Ismail SAS and Dessouki AA (2013). Pathological lesions survey and economic loss for male cattle slaughtered at Ismailia abattoir. *International Food Research Journal* 20(2): 857-863.
3. Aliyu MMJ, Adamu YJ, Bilyaminu YA (2009). Current Prevalence of Tuberculous Lesions among Slaughtered Cattle in Northeastern States of Nigeria. *Revue d'Elevage et de Medecine Veterinaire des Pays Tropicaux* 62 (1): 13-16.
4. Amanfu W (2006). The situation of tuberculosis and tuberculosis control in animals of economic interest. *Tuberculosis* 86: 330–335.

5. Ameen SA, Adedeji OS, Raheem AK, Leigh OO, Rafiu TA, and Ige AO (2008). Current Status of Bovine Tuberculosis in Ogbomoso Area of Oyo State. *Middle-East Journal of Scientific Research* 3 (4): 207-210.
6. Anonymous (2009). *Bovine tuberculosis*. Manual of diagnostic tests and vaccines for terrestrial animals: Office International des Epizooties (OIE).
7. Anonymous (2013). Michigan Department of Natural Resources. Wildlife Disease. Bovine Tuberculosis. <http://www.michigan.gov/dnr/0,1607,7-153-10370_12150_12220-99064--,00.html> (Accessed July, 2013).
8. Awah-Ndukum J, Kudi AC, Bradley G, Ane-Anyangwe IN, Fon-Tebug S, Tchoumboue J (2010). Prevalence of bovine tuberculosis in abattoirs of the Littoral and Western highland regions of Cameroon: A cause for public health concern. Veterinary Medicine International; doi:10.4061/2010/495015.
9. Ayele WY, Neill SD, Zinsstag J, Weiss MG and Pavlik I (2004). Bovine tuberculosis: An old disease but a new threat to Africa. *International Journal of Tuberculosis and Lung Disease* 8: 924–937.
10. Bikom PM and Oboegbulem SI (2007). Prevalence of suspected tuberculosis lesions in cattle slaughtered in cross river state abattoirs. *Nigerian journal of animal production* 34 (2): 301 – 305.
11. Brosch R, Gordon SV, Marmiesse M, Brodin P, Buchrieser C, Eiglmeier K, Garnier T, Gutierrez C, Hewinson G, Kremer K, Persons LM, Pym AS, Samper S, van Soolingen D, and Cole ST (2002). A new evolutionary scenario for the Mycobacterium tuberculosiscomplex. *Proceeding of the National Academy of Sciences USA* 99: 3684-3689.
12. Cadmus S, Palmer S, Melissa O, James D, Karen G (2006). Molecular Analysis of Human and Bovine Tubercle Bacilli from a Local Setting in Nigeria. *Journal of Clinical Microbiology* 44: 29–34.
13. Cadmus SI, Yakubu MK, Magaji AA (2010). *Mycobacteriumbovis*, but also *M africanum* present in raw milk of pastoral cattle in north-central Nigeria. *Tropical Animal Health Production* 42: 1047–1048.
14. Cassidy JP, Bryson DG, Pollock JM, Evans RT, Forster F and Neill SD (1998). Early lesion formation in cattle experimentally infected with *Mycobacterium bovis*. *Journal of Comparative Pathology* 119: 27-44.
15. Cosivi O, Grange JM, Daborn CJ, Ravijglione MC, Fujikura T, Cousins D (1998). Zoonotic tuberculosis due to *Mycobacterium bovis* in developing countries. *Emerging Infectious Diseases* 4: 59-70.
16. FAO (1994). A manual for the primary animal health care worker. Food and Agriculture Organization of the United Nations, Rome.
17. Ibironke AA and Fasina FO (2010). Socio-economic implications of bovine liver rejection in a major abattoir in south-western Nigeria. *Revista* de *CiênciasAgrárias* 33 (2) 211 – 216.
18. Igbokwe IO, Madaki IY, Danburam S, Ameh JA, Aliyu MM, Nwosu CO (2001). Prevalence of pulmonary tuberculous lesions in cattle slaughtered in abattoirs in North-Eastern Nigeria. *Revue d'Elevage et de Medecine Veterinaire des Pays Tropicaux* 54: 191–194.
19. Ita AY and Udofia SM (2005). Epidemiology and endemicity of pulmonary tuberculosis in southeastern Nigeria. *Southeast Asian journal of tropical medicine and public health* 36(2): 317 – 323.
20. Jenkins AO, Cadmus SIB, Venter EH, Pourcel C, Haure Y, Vergnaud C and Godfroid J (2011). Molecular epidemiology of human and animal tuberculosis in Ibadan, Southwestern Nigeria. *Veterinary Microbiology* 151: 139 – 147.
21. Kaneene JB and Thoen CO (2004). Tuberculosis. *Journal American Veterinary Medical Association* 224(5): 685 – 691.
22. Kumar A, Deshane JS, Crossman DK, Bolisetty S, Yan B, Kramnik I, Agarwal A and Steyn AKC. Heme Oxygenase-1-derived Carbon Monoxide Induces the *Mycobacterium tuberculosis* Dormancy Regulon. *Journal of Biology and Chemistry* 283(26): 18032–18039.
23. Kwaghe AY, Ameh JA, Ambali A, Gararawa JT, Bukar G and Jauro U (2011). A Retrospective Study on Bovine and Human Tuberculosis Cases in Maiduguri, Borno State. *Researcher* 3(4): 39 – 43.
24. Liebana E, Johnson L, Gough J, Durr P, Jahans K, Clifton-Hadley R, Spencer Y, Hewinson RG and Downs SH (2008). Pathology of naturally occurring bovine tuberculosis in England and Wales. *The Veterinary Journal* 176: 354–360.
25. Michel AL, Muller B, Van Helden PD (2010). *Mycobacterium bovis* at the animal-human interface: a problem, or not? *Veterinary Microbiology* 140: 371–381.
26. Milan, F., Sanchez, M., Toledo, P., Ramirez, C., and Saltillan M. A. (2000). Descriptive study of bovine and human TB in Queretaro, Mexico. *Review of Latinoamerican Microbiology* 42(1): 13 – 19.

27. Nwata JA, Umeononigwe CN, Abonyi GE and Onunkwo JI (2011). Retrospective study of bovine and human tuberculosis in abattoirs and hospitals in Enugu State, Southeast Nigeria. Journal of public health and epidemiology, 3(7): 329 – 336.
28. Rohonczy BE, Balachandran VB, Dukes WT, Payeur BJ, Rhyan CJ, Saari AD, Whiting LT, Wilson HS and Jarnagin LJ (1996). A Comparison of Gross Pathology, Histopathology, and Mycobacterial Culture for the Diagnosis of Tuberculosis in Elk (*Cervus elaphus*). *Canadian Journal of Veterinary Research* 60: 108-114.
29. Smith NH, Gordon SV, de la Rua-Domenech R, Clifton-Hadley RS, Hewinson RG (2006). Bottlenecks and broomsticks: the molecular evolution of *Mycobacterium bovis*. *National Review of Microbiology* 4: 670 – 681.
30. Thoen CO, Lobue P and De Kantor I (2006). The importance of *Mycobacterium bovis* as a zoonosis. *Veterinary Microbiology* 112: 339–345.
31. Thoen CO, Lobue P, Enarson DA, Kaneene JB and De Kantor IN (2009). Tuberculosis: A re-emerging disease of animals and humans. *Veterinaria Italiana* 45: 135–181.
32. Tweddle NE and Livingstone P (1994). Bovine tuberculosis control and eradication programs in Australia and New Zealand. *Veterinary Microbiology* 40: 23–39.
33. Vekemans M, Cartoux M, Diagbouga S, Dembele M, Kone B, Delafosse A (1999). Potential source of human exposure to *Mycobacterium bovis* in Burkina Faso, in the context of the HIV epidemic. *Clinical Microbiology and Infection* 5: 617-621.
34. Wentink GH, Frankena K, Bosch JC, Vandehoek JED, van den Berg TH (2000). Prevention of disease transmission by semen in cattle. *Livestock Production Science* 62: 207–220.
35. WHO (2006). The Control of Neglected Zoonotic Diseases. A route to poverty allevation. Geneva, World Health Organization. Ref Type: Report.
36. World Health Organization: Who report (2009). Global tuberculosis control, surveillance, planning, financing. Available at: http://www.who.int/tb/publications/ global_report/2009/pdf/full_report.pdf.