Original Article

Sahel Journal of Veterinary Sciences

Sahel J. Vet. Sci. Vol. 21, No. 3, Pp 10-15 (2024)
https://doi.org/10.54058/dxhp0n49

Article History
Received: 19-11-2023
Revised: 08-09-2024
Accepted: 18-09-2024
Published: 30-09-2024

Occurrence of Anaplasmosis among Cattle in Makurdi Metropolis, Benue State, Nigeria

[1]Atsuwe, T. S., [2]Adulugba, O. A., [3]Udo, E. J. and [4]Chikwendu, J. I.

[1]Department of Zoology, Joseph Sarwuan Tarka University, Makurdi, Benue State, Nigeria
[2]Department of Science Laboratory Technology, Benue State Polytechnic Ugbokolo, Nigeria
[3]Depatment of Microbiology, Federal University of Technology, Ikot Abasi, Akwa Ibom State, Nigeria
[4]Department of Parasitology and Entomology, Faculty of Biological Sciences, Nnamdi Azikiwe University, Awka, Nigeria

*Author for Correspondence: atsuweterese@gmail.com

ABSTRACT

Anaplasmosis, a tick-borne disease affecting cattle, poses significant economic challenges in Benue State, Nigeria. Despite its prevalence, detailed studies on its pathology and economic implications are limited. The study investigated the prevalence and seasonal occurrence of anaplasmosis in cattle, along with its distribution across different age classes and sexes. Blood samples were collected over a three-month period covering both dry and wet seasons. Samples were obtained from 432 cattle via jugular vein puncture and processed using the thin blood film method. Microscopic examination was conducted to detect tick-borne hemoparasites. Statistical analysis, employing the chi-square test, was performed to evaluate differences within categorical variables. Of the 432 cattle examined, 31.0% were males and 69.0% females. Female cattle exhibited a higher overall prevalence of infection (68.1%) compared to males (31.9%). A prevalence of 58.7% was recorded for the wet season compared to the dry season (41.3%), but the difference was not statistically significant ($P > 0.05$). Adult cattle had the highest prevalence of anaplasmosis (71.0%), followed by juveniles (14.6%) and calves (14.1%). Among males, adult cattle had the highest infection rate (28.3%), while among females, adult females had the highest prevalence (71.7%), with statistical significance at $P < 0.05$ compared to other age classes and sexes. The findings provide valuable insights into the epidemiology of anaplasmosis in cattle and underscore the importance of considering location, season, age class, and sex in disease management and control strategies.

Keywords: Anaplasmosis; Prevalence; Makurdi; Dry and Wet Season; Sex; Age.

INTRODUCTION

Anaplasmosis is a tick-borne disease caused by an obligate bacteria belonging to the genus *Anaplasma* (notably, *Anaplasma marginale* and *Anaplasma central*) of the order *Rickettsiales,* family *Anaplasmataceae* (Gisele *et al.,* 2014). Anaplasmosis infects Cattle, sheep, goats, buffalo, and some wild ruminants however, cattle have been found to be more susceptible to *Anaplasma* infection. It is transmitted by at least 20 ticks of various species including *Hyalomma* spp., *Rhipicephalus* spp., *Boophilus* spp., *Ixodes* spp., *Demacentor* spp., however *Boophilus microplus* is found to be the major transmitting agent (Tarun *et al.,* 2015). Mechanical transmission by biting flies Diptera (e.g. Tabanidae and Stomoxys) or blood-contaminated fomites act as alternative means of spread (Atsuwe *et al.,* 2021).

Transplacental transmission occurs when the organism is transmitted from dam to fetus. This transmission appears to occur during the second or third trimester of pregnancy (Shola *et al.,* 2018). Disease is mainly characterized by progressive hemolytic anemia associated with fever, jaundice, decreased milk production, miscarriage, hyperexcitability and in some cases sudden death (Gisele *et al.*, 2014).

The incubation period of the disease is about 2 - 12 weeks and is directly related to the infective dose. The disease occurs throughout the tropical and subtropical regions of the world (Bakken and Dumler, 2015). In the early stages of infection, *Anaplasma* spp. penetrates the erythrocytes of the host, and diagnosis is confirmed by the presence of the organism in Giemsa-stained blood smears. The two *Anaplasma* spp. are morphologically indistinguishable but are found in different parts of the erythrocyte in the periphery in the case of *A. marginale* and more centrally in the case of *A. centrale*. Anaplasmosis generally results in very mild or sub-clinical disease, but infection of adult animals with *A. marginale* can be severe, causing anaemia and up to 50% mortality (Kumar *et al*., 2015). Anaplasmosis mainly affects non-resistant exotic cattle, but local breeds of cattle can also be affected under conditions of poor health or nutrition. Animals that

recover from infection with either species of *Anaplasma* become carriers for life and can develop the disease again if subjected to stress (Amorim *et al.,* 2014). Anaplasmosis is therefore an important disease in endemic areas, where *A. marginale* can cause severe losses. Mixed infections can also occur (e.g. combinations of Babesia and Anaplasma), particularly if the causative agents share the same tick vector (Shola *et al.,* 2018).

Anaplasmosis can be effectively treated, especially in the early stages of infection, with tetracycline antibiotics (oxytetracyclines or chlortetracycline) and with imidocarb dipropionate. Acute cases may require blood transfusion and rehydration (Kumar *et al.,* 2015).

Bovine anaplasmosis is the major cause of morbidity and mortality in the tropics and subtropics, particularly in exotic and crossbred cattle. The geographic distribution of the disease is dependent on the density and distribution of tick vectors and reservoir host. The distribution of Anaplasmosis may continue to change due to the trend of global warming, which may influence the movement of the tick hosts (Tagesu *et al*., 2019).

Nigeria is the most populous African country, where the cattle population is of approximately 20 million heads, eighty percent of which are concentrated in the North-Central regions of the country (Lorusso *et al.,* 2016). A survey of vector-borne pathogens of cattle in Plateau state reported prevalence of *A. marginale*, *A. centrale* and *A. platys* (Kamani *et al.,* 2022). Another study conducted on cattle blood samples from Kwara, Katsina, Borno, Taraba and Benue state, Nigeria reported high prevalence of *Anaplasma* spp (Elelu *et al.,* 2016; Nyifi *et al*., 2023.*;* 2016 Zawua *et al*., 2014). Animals that have died due to anaplasmosis may show the following Pathological lesions such as pale to yellow tinged (jaundice) mucous membranes, thin watery blood, enlarged soft spleen with prominent follicles, enlarged liver with yellow-orange discoloration, gall bladder distension with thick green-brown bile, brown hepatic and mediastinal lymph nodes, epicardial and pericardial petechia, ecchymotic hemorrhages (Jaswal *et al*., 2015).

Cattle production in Benue State is however challenged with various constraints namely, grazing, limited access to capital, exploitation of the unconventional ingredients and by-product and a number of diseases such as Babesiosis, Theileriosis, Anaplasmosis and other related tick-borne haemoparasitic infections (Zawua *et al*., 2014). Among these constraints, Anaplasmosis has been reported as one of the major problems of cattle production in the State capital (Obadiah *et al.,* 2017). Anaplasmosis has contributed to severe economic losses which could be divided into direct and indirect. The direct production losses are those that are directly attributable to presence of disease in animal population through morbidity and mortality (Jemal, 2017). Other losses are related to the animals that recovered that may suffer from weight loss, lesions such as soft and pulpy spleen, damage and irritation to hide, swollen liver, dark-colored kidneys, anaemia and jaundice, produce low milk yields, reduction in meat, provide less draught power, and suffer from reduced fertility and delays in reaching maturity (Haranahalli *et al*., 2014; Kyari *et al*., 2022).This study was carried out to determine the prevalence of anaplasmosis in Makurdi metropolis, Benue State, Nigeria.

Materials and Methods

Study Area

Makurdi is one of the Local Government Areas and the state capital of Benue State Nigeria, (Figure 1). It is located in the North Central of Nigeria and shares boundary with Guma, Gwer, Gwer west and Tarka local government areas. The study sites comprise of four abattoirs one cattle market and a cattle farm namely, Wurukum abattoir, Wadata abattoir, Modern Market Abattoir, Cattle Market Abattoir North Bank, Cattle Market North Bank and Joseph Sarwuan Tarka University cattle farm (JOSTUM), Makurdi, Nigeria.

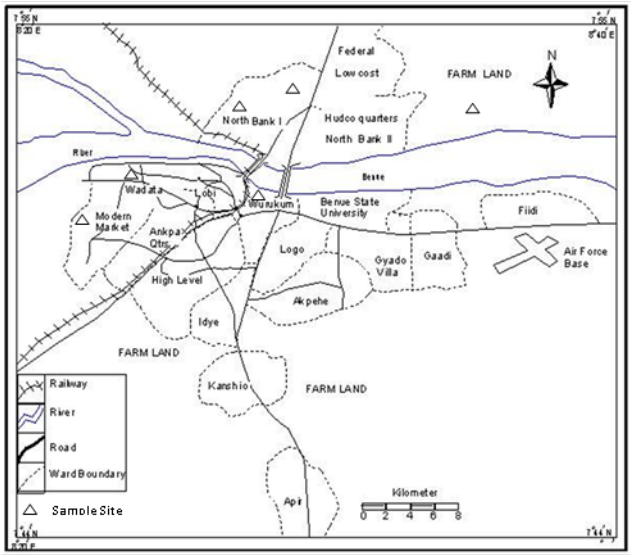

Figure 1: Map of Makurdi Local Government showing sampling sites (Tsor *et al.,* 2022).

Age Class Determination of Cattle

The approximate age of each cattle was determined using dentition according to the method described by Jane and Brandi, 2013.

Sample Size Determination and Sample Selection

A total of 432 cattle comprising of 216 cattle slaughtered at the abattoir were randomly sampled during the period of study. The age, breed, season (dry and wet), the ticks attached on the body of the cattle and other body conditions score were considered during sample selection. This size was arrived at using Taro Yamane's formulae (Adam, 2020)

$S = N/1 + N (e)$

S = sample

N = Population studied.

e = Error margin (0.05)

Sample Collection

Blood samples were collected from the study areas for the period of six (6) months December, January and February account for the dry season while June, July and August covers for the wet season. Blood samples were collected from the cattle by jugular vein puncture into a bijou bottle containing ethylenediaminetetraacetic acid (EDTA) used

as anti-coagulant. Each sample was labelled properly, placed in a cooler and transported immediately to Joseph Sarwuan Tarka University Veterinary Teaching Hospital Laboratory, Makurdi where it was examined using thin blood film method.

Sample analytical procedure

The sample was analysis using microscopic method (Thin blood film method).

Thin blood film method

A thin blood film technique was employed to detect tick borne haemoparasites of cattle using the following methods: the blood was mix gently with the aid of an applicator stick and few drops of blood was placed at the end of the slide at about 2cm to the edge of the slide. A separator was placed in front of the drops of blood and push backward to allow the separator to touch the drop (blood) and allowed to spray all to the sprayer. A firm push was made forward to make the blood dragged behind the separator slide to form a film, if the blood was pushed instead of pulled along the slide, parasite may be crushed. The procedure was completed as quickly as possible; the smear was allowed to dry and was labelled for proper identification. The smear was fixed in absolute methanol for five minutes and allowed to dry; the smear was covered with Giamsa stain (Romanowslay stain) and allowed for 35 to 40 minutes. The smear was washed with water and allowed to dry. The smear was viewed using the Microscope (100 objectives) oil immersion for identification of tick borne haemoparasites.

Statistical Analysis

Data obtained was analyzed using Chi-square test, to determine whether there is a significant different between the expected frequencies and the observed frequencies in one or more categories and to examine differences within categorical variables using SPSS 23.

RESULT

Cattle infected with anaplasmosis based on location and sex is presented on Table 1. A total of 432 cattle were examined out of which 134(31.0%) were males and 298(69.0%) were females. Out of these, 73 (31.9%) of the males were infected while 156 (68.1%) of the females were infected. Female therefore had the highest infection in the overall prevalence, with statistical difference (P >0.05) when compared with the male.

Seasonal Occurrence of Anaplasmosis

The result of seasonal occurrence of anaplasmosis is presented in Table 2. Wet season recorded the highest prevalence 98(58.7%) of anaplasma infection while the lowest prevalence 69(41.3%) was recorded in dry season though the difference was statistically significance when compared.

Table 1: Prevalence of Anaplasma Infection Based on Location and Sex of Cattle

	Sex				
Location	Infected Male %	Noninfected male %	Infected Female%	Noninfected male %	Total %
Wurukum abattoir	13(36.1)	10(27.8)	23(63.9)	26(72.2)	72(100.0)
Modern Market abattoir	7(24.1)	6(19.4)	22(75.9)	25(80.6)	60(100.0)
Cattle Market	23(46.0)	25(59.5)	27(54.0)	17(40.5)	92(100)
JOSTUM	16(34.0)	4(16.0)	31(66.0)	21(84.0)	72(100)
Cattle Market abattoir	4(13.8)	7(20.0)	25(86.2)	28(80.0)	64(100.0)
Wadata abattoir	10(26.3)	9(26.0)	28(73.7)	25(73.5)	72(100.0)
Total	73(31.9)	61(30.0)	156(68.1)	142(70.0)	432(100.0)

P > 0.05, $df = 15, x^2_{cal} = 39.67, x^2_{cri} = 24.99$

Table 2: Seasonal Occurrence of Anaplasma Infection on Studied Cattle

Season	Noninfected %	Infected %	Total %
Dry Season	147 (55.5)	69(41.3)	216(50.0)
Wet Season	118(44.5)	98(58.7)	216(50.0)
Total	265(100)	167(100.0)	432(100.0)

P > 0.05, $df = 1, x^2_{cal} = 8.21, x^2_{cri} = 3.84$

Prevalence of Anaplasmosis Across the Age Class and Sex of Cattle

Prevalence of tick borne haemoparasite across the age class of cattle is presented in Table 3. Adult, Juvenile and Calf were the age class of cattle examined for anaplasma infection. The highest prevalence of anaplasmosis was recorded among the adult cattle with the prevalence rate of 308(71 %) followed by juvenile age class with 63(14.6 %). The least prevalence of anaplasmosis was recorded in the calf 61(14.1 %) when compared. Adult male cattle recorded the highest infection of 45(28.30 %) and out of 156(68.10 %) females infected, the highest adult female cattle recorded 114(71.70 %), without statistical difference (p <0.05) with the other age class and sex.

Prevalence of Anaplasmosis in Benue State, Nigeria according to month.

Prevalence of anaplasmosis based on month of the year is shown in Figure 2. The highest prevalence of infection was seen in the month of June followed by the month of August. The month of December recorded the lowest prevalence of anplasmomsis.

Table 3: Prevalence of Anaplasmosis across the Age class and Sex of Cattle

Age class	Noninfected %	Infected male (%)	Sex Infected female (%)	Total %
Calf	21(10.3)	14(35.0)	26(65.0)	61(14.1)
Juvenile	33(16.3)	14(46.7)	16(53.3)	63(14.6)
Adult	149(73.4)	45(28.3)	114(71.7)	308(71.)
Total	203(100)	73(31.9)	156(68.1)	432(100)

P < 0.05, $df = 4, x^2_{cal} = 8.69, x^2_{cri} = 9.49$

Prevalence of Anaplasma base on Breed and Sex of Cattle

Prevalence of anaplasma based on breed and sex of cattle is presented on Figure 3. Breed of cattle studied were: White Fulani, Sokoto Gudali, Muturu, N'dama and West African Dwarf. African Dwarf cattle recorded the highest infection in female and the least infection in male.

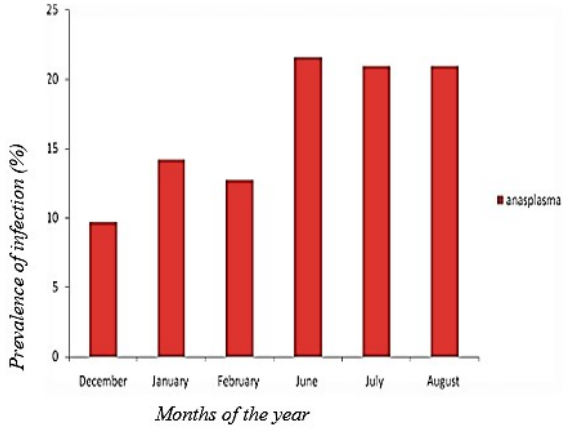

Figure 2: Prevalence Anaplasmosis in Benue State, Nigeria according to month.

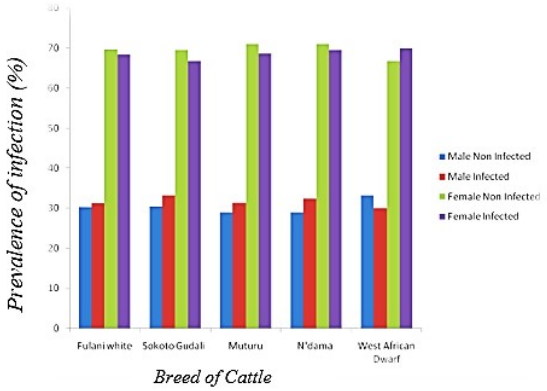

Figure 3: Prevalence of Anaplasma based on Breed and Sex of Cattle.

Occurrence of Anaplasmosis infection in cattle based on the age class and season of the year as shown in Figure 4. Recorded the highest infection in Calf among the studied cattle in the dry season, (58.60 %) and Juvenile recorded the lowest (41.40 %) prevalence of the infection. During Wet season, calf recorded highest (71.90 %) followed by adult and juvenile (52.90 % and 52% respectively) prevalence of the infection. When the two seasons were summed, Calf recorded the highest infective prevalence of 65.60 % while Juvenile recorded the lowest infective prevalence of (47.60 %).

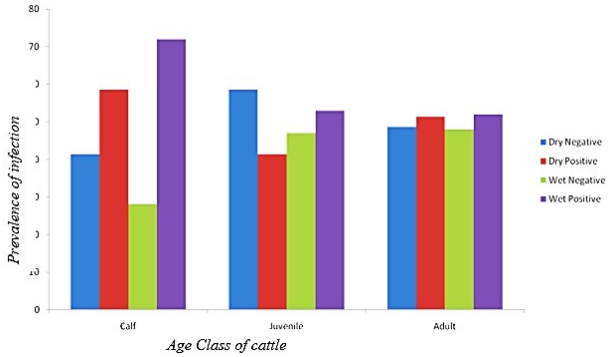

Figure 4: Occurrence of Anaplasmosis infection in cattle based on the age class and season of the year.

DISCUSSION

The result reveals the prevalence of Anaplamosis in cattle in the studied locations. Several pattern could contribute to this based on the observed fact that movement of cattle on the studied location was not restricted in addition to the prevalence of vector ticks in the grazing areas.

However, the result is not out of expectation as there have been reports on the occurrence of Anaplama infections in the neighboring areas. Obadiah *et al.* (2017) documented that *B. duoloratus*, *A. Variegatum*, *Hyacomma* spp and *B. Microplus* were the tick species infesting Markurdi metropolis. Adua and Idahor, (2017) also reported prevalence of Anaplamosis in Cattle and Goats Slaughtered at Lafia Abattoir, Nigeria. This result is in line with the study conducted by Zawua *et al*. (2015) who reported prevalence of Haemoparasites of cattle slaughtered for sale within Gboko Metropolis of Benue State, Nigeria. This also agrees with the work of Paul *et al*. (2017) who recorded prevalence of haemoparasite of Zebu cattle in Marilyn Northern Nigeria.

However, high prevalence of Anaplasma infection was recorded in this study at JOSTUM cattle farm. Poor veterinary services in this area could be considered as a contributory factor.

The prevalence of Anaplasmosis based on month of the year studied reveals high prevalence of Anaplasmosis in the month of June and August. Likely, there are favourable environmental conditions for the survival of the ticks that are responsible for the transmission of these diseases in these months. This result disagrees with the work of Opara *et al.* (2016) and Olorunshola *et al.* (2019)

who both reported high prevalence of Anaplasmosis in the month of December. Nwoha *et al.* (2019) reported a relatively low prevalence of tick-bone haemoparasites in the month of June, July and August who work on the prevalence of haemoparasites in livestock in Ikwnano Local Government Area of Abia State.

The result of comparison of cattle with anaplasmosis in relation to age class reveals highest prevalence of Anaplasma infection in adult cattle while the least prevalence of infection was recorded in Juveniles. Atsuwe *et al.* (2019) in his report pointed out a corresponding low prevalence of Anaplasmosis in cattle of juvenile cattle. In their report, they documented that high susceptibility of animals and reduced immunity are because of stress due to pregnancy, lactation and unfavorable environmental conditions. However, in their report, optimal environmental condition for survival and proliferation of arthropod vector are also responsible for the transmission of ticks in animal within the juvenile's age group. There have been reports that most cattle have their first pregnancy within this age class (Atsuwe *et al*., 2019).

It was observed that adult female cattle recorded the highest prevalence of the infection. This could be related to the issues associated with pregnancy and lactation; however, pregnancy and lactation have been reported to result in less immunity of female ruminant thereby making the animal immunocompromised and become highly prone to any environmental and other opportunistic infections. This result however disagrees with the report of Obadiah *et al*., (2017) in which male cattle were seen to have high prevalence of infection more than female ones.

The low prevalence of Anaplasma infection recorded within calf in the studies could not be attributed to the biting activities of the ticks since all simple were collected within the first and second day of delivery or birth. Hence infection could be due to transplacental transmission or vertical transmission from the dam to fetus. The female juvenile and adult pregnant cows were susceptible to ticks. The result agrees with the work Costa *et al* (2016) who reported *Anaplasma marginale* within the first 120 days of gestation in cows and positive calves within three (3) hours after birth.

Conclusion

Anaplasma infection in cattle recorded a high prevalence in the wet season. Calf recorded the highest infection during the dry and wet season in Makurdi metropolis, Benue State and this has resulted in high negative impact and economic loss. Thus, integrated control policies should be developed to take care of multi-species pathogen in communities that are commonly associated with clinical and sub-clinical anaplasmosis.

Conflict of Interest

The authors have no conflict of interest to declare.

Author's Contributions

ATS drafted the manuscript and conducted the laboratory work. AOA and OEJ developed the methodology and data analysis. CJI edited the manuscript. All authors approved the general manuscript.

REFERENCES

Adua, M. M. and Idahor, K. O. (2017). Haematological Evaluation of Haemoparasites in Cattle and Goats Slaughtered at Lafia Abattoir, Nigeria. *Asian Journal of Biology.* 4 (1): 1-5. https://doi.org/10.9734/AJOB/2017/35575.

Adam, A. M. (2020). Sample Size Determination in Survey Research. *Journal of Scientific Research & Reports* 26(5): 90-97. https://doi.org/10.9734/jsrr/2020/v26i530263.

Amorim L. S., Wenceslau, A. A., Carvalho F.S., Carneiro, P. L. and Albuquerque, G. R. (2014). Bovine babesiosis and anaplasmosis complex: diagnosis and evaluation of the risk factors from Bahia, Brazil. *Brazilian Journal of Veterinary Parasitiology.*23 (3): 328-336. https://doi.org/10.1590/S1984-29612014064

Atsuwe T.S., Amuta E. U., Imandeh G. N. and Azua E.T. (2021). Seasonal Occurrence of Tick-Borne Haemoparasite of Cattle in Makurdi Metropolis, Benue State, Nigeria Journal of *Animal Husbandry and Dairy Science*. 5, (1) 10-16. https://doi.org/10.22259/2637-5354.0501002

Atsuwe, T. S., Azua, E. T., Obisike, V. U. and Imandeh, G. N. (2019). Comparative study on tick–borne Haemoparasite of Cattle and Goats slaughtered in some Abattoirs within Makurdi; Nigeria. *Journal of Applied Life Science International*. 19 (4): 1-6. https://doi.org/10.9734/JALSI/2018/46280.

Bakken, J. S. and Dumler, S. (2015). Human Granulocytic Anaplasmosis. *Infectious Disease Clinics of North America.* 29: 341-355. https://doi.org/10.1016/j.idc.2015.02.007

Costa, S.C., De Magathcie, V.C., De Olivira, U.V., Carvello, F.S., De Almeida, C.P., Machado, R.Z. and Munhoz, A.D. (2016). Transpacental transmission of bovine tick-borne pathogens: Frequency co-infection and fatal neonatal anaplasmosis in a region of enzootic stability in the northeast of Brazil. *Ticks Tick Borne Dis 7:270-275.* https://doi.org/ 10.1016/j.ttbdis.2015.11.001.

Elelu, N., Ferrolho. J., Couto, J., Domingos, A. and Eisler, M. C. (2016). Molecular diagnosis of the tick-borne pathogen *Anaplasma marginale* in cattle blood samples from Nigeria using qPCR. *Experimental and Applied Acarology.*70:501–510. https://doi.org/10.1007/s10493-016-0081-y

Gisele, M. B., Carlos, A. N and Flábio, R. A. (2014). Molecular diagnosis of *Anaplasma marginale* in cattle: quantitative evaluation of a real-time PCR (Polymerase Chain Reaction) based on msp5 gene. *Pesquisa Veterinária Brasileira.* 34 (1):29-33. https://doi.org/10.1590/S0100-736X2014000100005.

Haranahalli, V. M., Buddhi, C. S., Manickam, K., Kumaragurubaran, K., Prakashkumar, R., Marappan, G., Paramasivam, T., and Bharemara, L. B. (2014). Economic importance of ticks and

their effective control strategies. *Asian Pacific Journal of Tropical Disease,4*(2), S770–S779. https://doi.org/10.1016/s2222-1808(14)60725-8.

Jane, A. P and. Brandi, B. K. (2013). Estimating cattle age using Dentition. Publication by Extension Service of Mississippi state University, Cooperating with U.S Department of Agriculture. Pp1-7.

Jaswal, H., Bal, M. S., Singla, L. D., Gupta, K. and Brar, A. P. S. (2015).Pathological observations on clinical *anaplasma marginale* infection in cattle. Journal of parasitic diseases. 39 (3): 495–498. *https://doi.org/*10.1007/s12639-013-0384-4.

Jemal, J. Y. (2017). Review on bovine babesiosis and its economic importance. *Journal of Veterinary Medicine and Research,4* (5), 1090. https://doi.org/10.47739/2378-931X/1090

Kamani, J., Schaer, J., Umar, A.G., Pilarshimwi, J.Y., Bukar, L., Gonzalez-Migue, J. and Harrus, S. (2022). Molecular detection and genetic characterization of *Anaplasma marginale* and *Anaplasma platys* in cattle in Nigeria. *Ticks and Tick-borne Diseases*, 13 (4), 101955. *https://doi.org/*10.1016/j.ttbdis.2022.101955.

Kumar, T., Sindhu, N., Charaya, G., Kumar, A., Kumar, P., Chandratere, G., Agnihotri, D. and Khurana, R. (2015). Emerging status of anaplasmosis in cattle in Hisar. *Veterinary World.* 85050 (6): 768-771. https://doi.org/10.14202/vetworld.2015.768-771.

Kyari, S., Ogwiji, M., Igah, O.E. Khadijat, A. and Gasaliyu*et,* K., A. (2022). Current distribution and disease association of Ixodidae (hard ticks) in Nigeria. *Journal of Basic and Applied Zoology* 83, 42-48. https://doi.org/10.1186/s41936-022-00304-8.

Lorusso, V., Wijnveld, M., Majekodunmi, A. O., Dongkum, C., Fajinmi, A., Dogo, A. G., Thrusfield, M., Mugenyi, A., Vaumourin, E., Igweh, A. C., Jongejan, F., Welburn, S. C., and Picozzi, K. (2016). Tick-borne pathogens of zoonotic and veterinary importance in Nigerian cattle. *Parasites & vectors*, *9*, 217. https://doi.org/10.1186/s13071-016-1504-7.

Nwoha, R. I. O., Onyeabor, A., Igwe, K. C., Daniel-Igwe, G., Onuekwusi, G. C. O. and Okah, U. (2019). Prevalence of haemoparasites in livestock in Ikwuano Local Government Area of Abia State. *Journal of Fisheries & Livestock Production.* 1 (3): 43-49. https://doi.org/doi:10.4172/2332-2608.1000109.

Nyifi, A.S., Ahmadu, P.J. and Mamtso, J. (2023). prevalence of anaplasmosis in small ruminants in some selected livestock farms in wukari metropolis taraba state nigeriar. *FUDMA Journal of Agriculture and Agricultural Technology.* 9 (3): 52 -57. https//doi.org/ 10.33003/jaat.2023.0901.27

Obadiah, H. I., Onah, I. E., Ugoochuku, C. and Gbinde, A.K. (2017). Tick infestation of cattle in three markets in Makurdi, North – Central, Nigeria. *American Journal of Entomology*. 1 (1): 6 – 10. https://doi.org/10.11648/j.aje.20170101.12.

Opara, M. N., Santali, A., Mohammed, B. R. and Jegede, O. C. (2016). Prevalence of haemoparasites of small ruminants in Lafia Nassarawa State: A guinea savannah zone of Nigeria. *Journal of Veterinary Advances.* 6(6): 1251–1257. https://doi.org/10.5455/jva. 1969123104000000.

Paul, B. T., Bello, A. M., Haruna, N. M., Dauda, J., Ojo, T. D. and Gadzama, M. A. (2017). Infestation of Zebu cattle (*Bos indicus* Linnaeus) by hard ticks (Acari: Ixodidae) in Maiduguri, North eastern Nigeria. *Persian J. Acarol.* 6(3):213-224. https://doi.org/ 10.22073/pja.v6i3.28203.

Shola, D. O., Fufa, I. G., Donea, A. A., Reuben, S. K., Sharmad, J. F. and Rehana, A. S. (2018). Epidemiology and risk factors associated with *Anaplasma marginale* infection of cattle in Peninsular Malaysia. *Parasitology International.* 67; 659-665. https://doi.org/10.1016/j. parint.2018.06.013.

Tagesu, A., Roba, H., Tolera, T., Gemechu, R. and Getachew, T. J. (2019). Epidemiology of bovine anaplasmosis. *SOJ Vet Sci.* 5 (1): 1-6. https://doi.org/10.15226/2381-2907/5/1/00165.

Tarun, K. N., Gaurav, C., Ankit, K., Parmod, K., Gauri, C., Divya, A., Rajesh, K. (2015). Emerging status of anaplasmosis in cattle in Hisar. *Veterinary World.* 8 (6):768-771. https://doi.org/10.14202/vetworld.2015.768-771.

Tsor, J.O., Biam, J.T., Terver, D., Shimlumun, A.P., and Jombo G.T.A. (2022). Assesment of physico-chemical parameters and Heavy metal concentrations in well water of hogo z Area of Makurdi, Nigeria. *Nigerian Annals of pure and Applied sciences*. 5(1): 137-148. https://doi.org/10.5281/zenodo.6905019.

Zawua, T. P., Amali, O., Amuta, E. U. and Sar, T. T. (2015). Haemoparasites of cattle slaughtered for sale within Gboko Metropolis of Benue State, Nigeria. *Nigerian Journal of Parasitology.* 36(1): 72-76. https://doi.org/ 10.4314/NJPAR.V36I1.