Journal of Science, Management and Technology
ISSN (Print): 1597-7463; eISSN (Online): 2811-2598, Volume 6, Issue 1
https://dx.doi.org/10.4314/hpjsmt.v6i1.14

Prevalence of *Trypanasomiasis* in Northern Nigeria: A Review

[1]Haruna Abubakar Danyayam, [2]Anas Muazu Abdullahi,

[1] Department of Science Laboratory Technology, Hussaini Adamu Federal Polytechnic Kazaure.

[2]Department of Science Laboratory Technology, Federal Polytechnic Daura.

Corresponding Author's Email:

[1]abubakarharuna34y@gmail.com, [2]anasmuazu@fedpolydaura.edu.ng

Abstract

Trypanosomiasis, a parasitic disease caused by protozoan parasites of the genus Trypanosoma, is a significant public health concern in sub-Saharan Africa, including Northern Nigeria. The disease, transmitted by tsetse flies, poses a significant threat to human health, livestock production, and economic development. Animal African trypanosomiasis (AAT), also known as Nagana, is caused by various trypanosome species, including T. brucei, T. congolense, T. vivax, T. equiperdum, T. evansi, T. simiae, T. suis, and T. theileri. Cattle are the most affected, but other animals such as goats, dogs, sheep, pigs, and wild animals are also susceptible. Symptoms of AAT include parasitaemia, anemia, loss of weight, reduced productivity, and high mortality, which limit the pace of rural development in tropical Africa. The current threat of AAT ranks among the top cattle diseases on sustainable livestock production and mixed farming. At least 3 million livestock deaths each year are caused by AAT, with a loss in livestock production and mixed agriculture valued at $5 billion US dollars yearly in Africa. Effective and sustainable control measures can result in up to threefold increases in the estimated livestock population in Nigeria. Trypanosomiasis is considered a haemoparasites, posing a major threat for the development of the cattle industry in Africa, Asia, and Latin America. It kills a variety of domestic and wild animals and causes anemia, weight loss, miscarriage, and productivity losses. In Northern Nigeria, both human African trypanosomiasis (HAT) and animal African trypanosomiasis (AAT) are prevalent. The epidemiology of trypanosomosis depends on the distribution of vectors, the virulence of the parasite, and the host's response.

Key words: Prevalence, Animals, *Trypanasomiasis*, Tsetse fly and Northern Nigeria.

Introduction

Trypanosomiasis, a parasitic disease caused by protozoan parasites of the genus *Trypanosoma*, is a significant public health concern in sub-Saharan Africa, including Northern Nigeria (Kasozi *et al*., 2021). The disease, transmitted by tsetse flies, poses a significant threat to human health, livestock production, and economic development (Rebuma *et al*., 2024). Animal African *trypanosomiasis* (AAT), also known as Nagana, is

Journal of Science, Management and Technology
ISSN (Print): 1597-7463; eISSN (Online): 2811-2598, Volume 6, Issue 1
https://dx.doi.org/10.4314/hpjsmt.v6i1.14

caused by various trypanosome species, including *T. brucei, T. congolense, T. vivax, T. equiperdum, T. evansi, T. simiae, T. suis, and T. theileri* (Maichomo *et al*., 2021). Cattle are the most affected, but other animals such as goats, dogs, sheep, pigs, and wild animals are also susceptible (Yadav *et al*., 2023).

Symptoms of AAT include parasitaemia, anemia, loss of weight, reduced productivity, and high mortality, which limit the pace of rural development in tropical Africa (Venturelli *et al*., 2022). The current threat of AAT ranks among the top cattle diseases on sustainable livestock production and mixed farming (Van Eenennaam & Werth, 2021), and the failure of vector control and chemotherapy/chemoprophylaxis to control the disease presents a major constraint and drawback in the development of the African continent (Torka, 2023).

At least 3 million livestock deaths each year are caused by AAT, with a loss in livestock production and mixed agriculture valued at $5 billion US dollars yearly in Africa (Onyango *et al*., 2022). Effective and sustainable control measures can result in up to threefold increases in the estimated livestock population in Nigeria (Sikiru *et al*., 2023). This study aims to determine the prevalence of trypanosomes in the Katsina State of Northern Nigeria among herds of cattle.

Vector for *trypanosomiasis*

The tsetse fly is a vector for *trypanosomiasis*, a group of parasitic diseases that affect humans and animals. Tsetse flies become infected with trypanosomes when they feed on an infected animal, which multiply within their salivary glands (Abera, 2022). When the infected fly bites a healthy animal or human, it injects the trypanosomes into the bloodstream, leading to infection. There are several species of tsetse flies with varying geographical ranges and susceptibility to specific *trypanosoma* species (Wamwiri & Auma, 2021). Tsetse flies prefer shaded, humid environments with dense vegetation, often near water sources or areas with livestock.

Figure 1: Plate showing Tsetse fly (Opiro *et al*., 2021)

Journal of Science, Management and Technology
ISSN (Print): 1597-7463; eISSN (Online): 2811-2598, Volume 6, Issue 1
https://dx.doi.org/10.4314/hpjsmt.v6i1.14

Trypanosomiasis can have devastating effects on human health and livestock productivity, leading to significant economic and social consequences (Kikwai & Ngeiywa, 2022). Understanding the vector role is crucial for developing effective control strategies for *trypanosomiasis*, including fly control through methods like insecticide spraying, trapping, and habitat modification, and disease prevention through early diagnosis, treatment, vaccination, and drug development.

Taxonomy and classification of *trypanosomiasis*.

Kingdom: Protista
Phylum: Protozoa
Sub-phylum: *Sarcomastigophora*
Class: *Kinetoplastea*
Order: *Trypanosomatidae*
Family: *Trypanosoma*
Genus: *Trypanosoma*

Trypanosomiasis is considered as haemoparasites. Haemoparasites poses major threat for the development of the cattle industry in Africa, Asia, and Latin America (Kasozi, 2021). The species has spread far beyond its primary territory (sub-Saharan Africa) and now affects livestock in Northern Africa, Asia, Central America, and South America (Clemmons et el., 2021). This disease is of great concern to many developing countries such as Sudan, where the large camel population (estimated at over 4.6 million heads) is at risk (Megersa *et al*.; 2021). *trypanosomiasis* kills a variety of domestic and wild animals and causes anemia, weight loss, miscarriage, and productivity losses (Hossain *et al*, 2023). It also causes adverse consequences in a variety of organs, such as the kidney, liver, brain, and spleen (Gupta, 2020).

Epidemiology of *trypanosomiasis* in Northern Nigeria

Northern Nigeria is a major endemic region for *trypanosomiasis*, with both human African *trypanosomiasis* (HAT) and animal African *trypanosomiasis* (AAT) prevalent.

Trypanosomes are found in Northern Nigeria where the tsetse fly vector exists, primarily determined by its ecology. *T. congolense* and *T. vivax* cause severe disease in cattle, sheep, and goats, while *T. brucei* causes subclinical infection in cattle but severe disease in sheep, goats, horses, and occasionally pigs. *T. simiae* causes acute and highly fatal disease in exotic pigs but is not pathogenic to cattle, sheep, or goats (Takeet, 2015). The epidemiology of trypanosomosis depends on the distribution of vectors, the virulence of the parasite, and the host's response (Morrison *et al*., 2023). *T. vivax* is found in South and Central America and the Caribbean, where other biting flies act as mechanical vectors to spread the disease (Steverding *et al*., 2023). Affected countries include Bolivia, Brazil, Colombia, French Guiana, Guyana, Peru, Suriname, and Venezuela, where it mainly affects cattle and sheep (Dorsch *et al*., 2021).

Journal of Science, Management and Technology
ISSN (Print): 1597-7463; eISSN (Online): 2811-2598, Volume 6, Issue 1
https://dx.doi.org/10.4314/hpjsmt.v6i1.14

Human African *trypanosomiasis* (HAT):

HAT, also known as sleeping sickness, is caused by *Trypanosoma brucei gambiense* and *Trypanosoma brucei rhodesiense*. While *T. b. gambiense* is responsible for most cases in Nigeria, T. b. rhodesiense is also present in some areas. The distribution of HAT in Northern Nigeria is linked to the presence of tsetse flies and the proximity of human settlements to endemic areas (Odeniran, 2020).

Recent studies indicate a decreasing trend in HAT cases in Northern Nigeria, with estimates suggesting a prevalence rate of less than 1% in some areas (Ogunrinde *et al*., 2021). However, pockets of high transmission persist, particularly in rural communities with limited access to healthcare and vector control measures.

Animal African *trypanosomiasis* (AAT), also known as nagana, is a widespread disease affecting domestic animals, primarily cattle in Northern Nigeria, causing significant economic losses in livestock production (Odeniran, 2020).

Journal of Science, Management and Technology
ISSN (Print): 1597-7463; eISSN (Online): 2811-2598, Volume 6, Issue 1
https://dx.doi.org/10.4314/hpjsmt.v6i1.14

Table 1: Some research conducted on Prevalence of *trypanasomiasis* in Northern Nigeria

Author/Year	Title	Location/state	Study population	Results/Prevalence
Usman *et al*., (2024)	Detection and Epidemiology of Trypanosome Infection in Livestock at Katsina Abattoir: Implications for Biosecurity and Animal Health in Northern Nigeria. *UMYU Scientifica*, *3*(4), 300-310.	at Katsina Abattoir	Livestock	This study examines the prevalence and impact of African Animal Trypanosomiasis in livestock slaughtered at Katsina Central Abattoir in Nigeria. The study found that non-healthy animals had significantly lower packed cell volume values, correlating with trypanosome infections. Molecular analysis confirmed the presence of Trypanosoma evansi in the camel. The findings suggest the need for enhanced diagnostic techniques, robust biosecurity measures, public awareness, and informed policy decisions to mitigate the spread of trypanosomiasis, especially in regions exposed to cross-border livestock movement.
Habeeb *et al*.; 2023	Molecular identification and prevalence of *trypanosomes* in cattle distributed within Jebba axis of the Rive r Niger, Kwara state, Nigeria.	Jebba axis of the River Niger, Kwara state	Cattles	Out of 398 animals tested, 3 cattles was tested positive by microscopy representing 0.8% and 3.0% tested using PCR.
Asabe *et al*., 2020	The prevalence of natural mixed infection of *T. congolense* and *T. vivax* in cattle from selected abbatoirs in Kaduna metropolis, Kaduna state.	Kaduna metropolis, Kaduna state.	Cattles.	Out of 300 samples examined, A total prevalence of 1.3% from Kawo and Tudunwada abbatoirs was observed.
Lema *et al*., 2018.	Prevalence of bovine *trypanasomiasis* in katsina central abbatoir, katsina state.	Katsina central abbatoir, Katsina state	Cattles	200 cattles was diagnosed, 3 cattle was found positive. This indicates 1.5% prevalence

Journal of Science, Management and Technology
ISSN (Print): 1597-7463; eISSN (Online): 2811-2598, Volume 6, Issue 1
https://dx.doi.org/10.4314/hpjsmt.v6i1.14

Wayo, 2017	Prevalence of *Trypanosomiasis* in sheep in the Kachia grazing reserve, Kachia, Kaduna State, Nigeria	Kachia grazing reserve, Kaduna state.	Sheeps	A total of 45 (40.9%) animals were found positive. The *trypanosomes* observed were *T. congolense* (40.0%), *T. Brucei* (28.8%), *T. vivax* (17.7%) and mixed infections (13.3%)
Karshima *et al*.; 2016	Animal reservoirs of *Trypanosoma brucei gambiense* around the old Gboko sleeping sickness focus in Nigeria	Gosko LGA of Benue State.	Cattles/Pigs	46 out 600 cattles and 72 out 600 pigs was tested positive for different species of trypanosomes.

Journal of Science, Management and Technology
ISSN (Print): 1597-7463; eISSN (Online): 2811-2598, Volume 6, Issue 1
https://dx.doi.org/10.4314/hpjsmt.v6i1.14

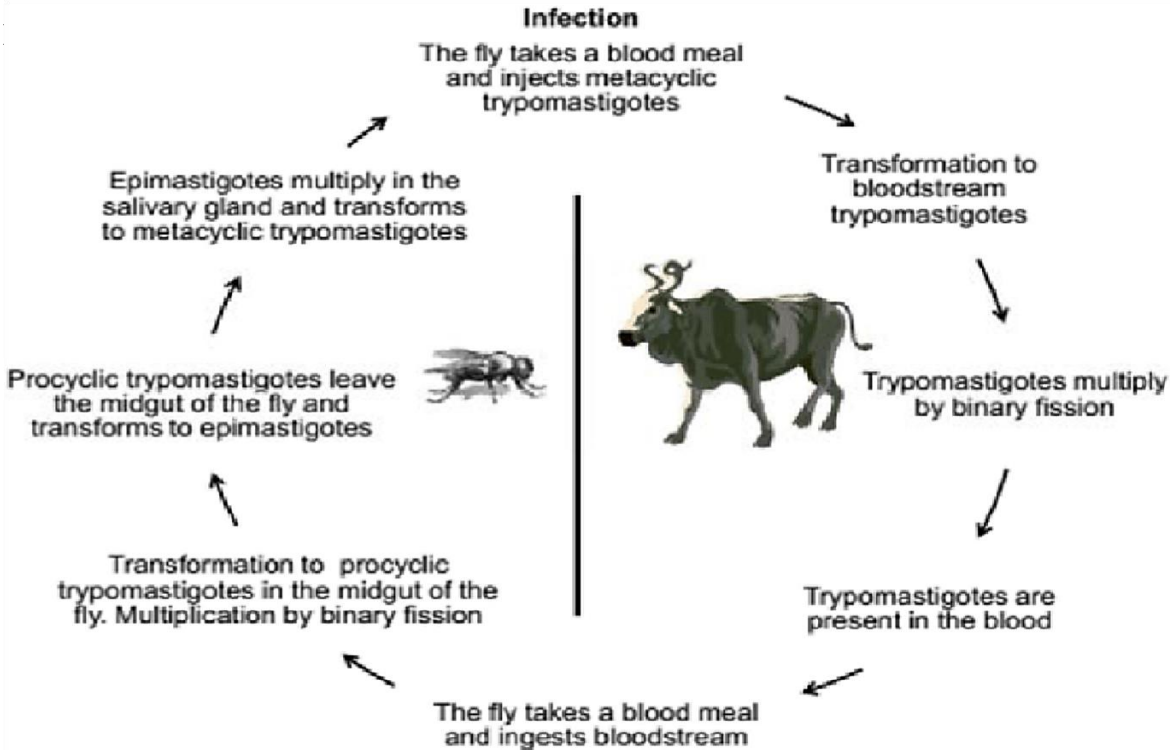

Figure 2: A Pate showing Life Circle of Tsetse fly (Rebuma *et al*, 2024)

Taxonomy and classification of *trypanosomiasis*.
Kingdom: Protista
Phylum: Protozoa
Sub-phylum: *Sarcomastigophora*
Class: *Kinetoplastea*
Order: *Trypanosomatidae*
Family: *Trypanosoma*
Genus: *Trypanosoma* (Algehani, *et al*., 2021)

The tsetse fly, a vector of African *trypanosomiasis* (sleeping sickness), has a complex life cycle that is crucial for controlling its spread. The female tsetse fly carries a single egg within her uterus, which undergoes initial development and is nourished by the "milk gland." The larva hatches and grows rapidly, undergoing three instars within the uterus. The pupa stage, where the larva undergoes metamorphosis into an adult fly, can last from a few weeks to several months (Sarwar, 2020). The adult fly emerges from the pupa, ready to mate and begin its blood-feeding cycle. Adult females typically live for several months, while males have a shorter lifespan. Adult tsetse flies transmit the trypanosome parasites that cause sleeping sickness. The trypanosomes multiply within the fly's salivary glands and are injected into the

Journal of Science, Management and Technology
ISSN (Print): 1597-7463; eISSN (Online): 2811-2598, Volume 6, Issue 1
https://dx.doi.org/10.4314/hpjsmt.v6i1.14

bloodstream when an infected fly bites a healthy host. Understanding this life cycle is essential for controlling the spread of this debilitating disease (Sarwar, 2020).

Risk Factors for *trypanosomiasis* in Northern Nigeria

Several factors contribute to the prevalence of *trypanosomiasis* in Northern Nigeria, this including:

Environmental factors: The presence of tsetse flies is crucial for transmission. Northern Nigeria provides an ideal breeding ground for these insects, characterized by humid and wooded areas, particularly along riverine regions. The dense vegetation and ample water sources create a favorable environment for tsetse fly proliferation, increasing the risk of transmission (Kuye, 2020).

Human activities: Agricultural practices, such as bush clearing and deforestation, can inadvertently disrupt natural habitats and create new areas suitable for tsetse fly colonization. The removal of trees and vegetation reduces natural predators of tsetse flies, allowing their populations to thrive. Additionally, the increased movement of people and livestock through these areas facilitates the spread of the disease (Nagel & Peveling, 2021).

Trypanosomiasis in animals is caused by the infection of metacyclic trypanosomes by tsetse, which cause localized inflammation and enter the lymph and lymph nodes (Mabille & Caljon, 2020). The immune response is vigorous, leading to inflammation and fever. Antibodies against surface-coat glycoproteins kill trypanosomes, but trypanosomes have a large family of genes that code for variable surface-coat glycoproteins that switch in response to antibody responses, evading immunity (Đaković *et al*., 2023). This antigenic variation prevents the development of a protective vaccine and permits reinfections when animals are exposed to new antigenic types.

The severity of *trypanosomiasis* varies with species and age of the animal infected and the species of trypanosome involved. Incubation usually lasts 1-4 weeks, with primary clinical signs being intermittent fever, anemia, and weight loss (Shiferaw & Unviresty, 2021). Cattle usually have a chronic course with high mortality, especially if there is poor nutrition or other stress factors. Necropsy findings vary and are nonspecific, with acute, fatal cases involving extensive petechiation of serosal membranes, lymph nodes and spleen swelling, and chronic cases swollen lymph nodes, serous atrophy of fat, and anemia (Sede Di Grosseto, 2022).

Prevention efforts for *trypanosomiasis* include vector control, as the number of disease control methods within vertebrate hosts is limited and resistance to trypanocidal drugs makes chemotherapy difficult to sustain (Kasozi, 2022). The Veterinary Research Institute of Sudan (VRI) has conducted an exercise on a national level mapping to build a geo-referenced database of tsetse flies and bovine trypanosomosis in Sudan, supported by the Food and Agriculture Organization of the United Nations (FAO).

Control Strategies for *trypanosomiasis* in Northern Nigeria

Effective control of *trypanosomiasis* in Northern Nigeria necessitates a comprehensive and multifaceted approach, encompassing various strategies to disrupt the disease transmission cycle.

Journal of Science, Management and Technology
ISSN (Print): 1597-7463; eISSN (Online): 2811-2598, Volume 6, Issue 1
https://dx.doi.org/10.4314/hpjsmt.v6i1.14

Vector Control

Tsetse fly control is paramount in reducing disease transmission. Key measures include: Insecticide-Treated Nets (ITNs): ITNs serve as a crucial barrier against tsetse fly bites, particularly during vulnerable sleeping hours. The use of insecticide-impregnated netting provides an effective means of personal protection, shielding individuals from the biting flies that carry the trypanosome parasite (Orsborne, 2020).

Insecticide-Treated Cattle: Treating cattle with insecticides plays a pivotal role in reducing the overall tsetse fly population. By targeting the primary host of the parasite, this strategy disrupts the transmission cycle, limiting the flies' access to infected animals and consequently reducing the spread of *trypanosomiasis*.

Tsetse fly traps and targets: These devices attract and kill tsetse flies, effectively reducing their population.

Disease treatment: Prompt diagnosis and treatment are essential for preventing the development of severe complications. Effective drugs are available for both HAT and AAT (Orsborne, 2020).

Surveillance and monitoring: Continuous surveillance and monitoring programs are needed to track disease prevalence and identify areas with high transmission rates.

Public education and awareness: Educating the public about *trypanosomiasis*, its transmission, and prevention measures is crucial for reducing the burden of the disease (Orsborne, 2020).

Challenges and Future Directions

Despite ongoing efforts, significant challenges remain in controlling *trypanosomiasis* in Northern Nigeria:

Limited resources: Insufficient funding and human resources hamper the implementation of effective control programs.

Lack of access to healthcare: Many communities in Northern Nigeria lack access to healthcare facilities, leading to delayed diagnosis and treatment.

Limited research: More research is needed to develop new control strategies, improve diagnostics, and understand the factors influencing disease transmission (Njom *et al*., 2024).

Conclusion

Trypanosomiasis continues to pose a significant threat to human and animal health in Northern Nigeria. The disease's prevalence is influenced by a complex interplay of environmental, social, and economic factors. While progress has been made in controlling the disease, further efforts are needed to improve access to healthcare, strengthen surveillance systems, and develop innovative control strategies. By addressing these challenges, we can work towards reducing the burden of *trypanosomiasis* and improving the health and well-being of communities in Northern Nigeria.

Journal of Science, Management and Technology
ISSN (Print): 1597-7463; eISSN (Online): 2811-2598, Volume 6, Issue 1
https://dx.doi.org/10.4314/hpjsmt.v6i1.14

Recommendations.

1. There is need to employ other sensitive methods like PCR and ELISA to the true picture of *trypanosomosis.*
2. There is need to enlighten the cattle owners and herdsmen about the effect of the disease on their animals and its economic significance.
3. Since the study is only limited to the prevalence of *Trypanosomosis* in cattle and sheep, it's recommended that a further studies of goats and other domestic animals to be done to ascertain the parasite in our daily meat consumptions.
4. To expand the diagnosis of *trypanasomiasis* to all our abbatoirs.
5. To further enlighten the general public on the effects and implications of *trypanasomiasis* disease.

References

Abera, A. T. (2022). Prevalence of Bovine Trypanosomosis, Vector Distribution and Infection Proportion in Three Districts of Gamo Zone, Southern Ethiopia (Doctoral dissertation, HU).

Asabe MA, Ajakaiye JJ, Danladi LO et.al. The prevalence of natural mixed infection of *T. congolense and T. vivax* in cattle from selected abattoirs in Kaduna metropolis, Kaduna State, Nigeria. Int J Health Sci Res. 2020; 10(11):58-65.

Algehani, A. M. G., Jaber, F. A., Khan, A., & Alsulami, M. N. (2021). Review on trypanosomiasis and their prevalence in some country on the Red Sea. *Brazilian Journal of Biology*, *83*, e251671.

Clemmons, E. A., Alfson, K. J., & Dutton III, J. W. (2021). Transboundary animal diseases, an overview of 17 diseases with potential for global spread and serious consequences. *Animals*, *11*(7), 2039.

Đaković, S., Zeelen, J. P., Gkeka, A., Chandra, M., van Straaten, M., Foti, K., & Stebbins, C. E. (2023). A structural classification of the variant surface glycoproteins of the African trypanosome. *PLOS Neglected Tropical Diseases*, *17*(9), e0011621.

Dorsch, M. A., Cantón, G. J., Driemeier, D., Anderson, M. L., Moeller, R. B., & Giannitti, F. (2021). Bacterial, protozoal and viral abortions in sheep and goats in South America: A review. *Small Ruminant Research*, *205*, 106547.

Gupta, P. K., & Gupta, P. K. (2020). Target organ toxicity. *Problem Solving Questions in Toxicology: A Study Guide for the Board and other Examinations*, 83-117.

Habeeb IF, Chechet GD and Kwaga JKP. Molecular identification and prevalence of *trypanosomes* in cattle distributed within the Jebba axis of the River Niger, Kwara state, Nigeria. Parasites & vectors 2021. DOI: 10.1186/s13071-021-05054-0

Hossain, M. S., Hatta, T., Labony, S. S., Kwofie, K. D., Kawada, H., Tsuji, N., & Alim, M. A. (2023). Food-and vector-borne parasitic zoonoses: global burden and impacts. *Advances in Parasitology*, *120*, 87-136.

Kasozi, K. I., Zirintunda, G., Ssempijja, F., Buyinza, B., Alzahrani, K. J., Matama, K., & Welburn, S. C. (2021). Epidemiology of *trypanosomiasis* in wildlife—implications for humans at the wildlife interface in Africa. *Frontiers in Veterinary Science*, *8*, 621699.

ISSN (Print): 1597-7463; eISSN (Online): 2811-2598, Volume 6, Issue 1
https://dx.doi.org/10.4314/hpjsmt.v6i1.14
Kasozi, K. I., MacLeod, E. T., Ntulume, I., & Welburn, S. C. (2022). An update on African trypanocide pharmaceutics and resistance. *Frontiers in Veterinary Science*, *9*, 828111.

Kuye, R. A. (2020). Epidemiology of tsetse flies in the transmission of *trypanosomiasis*: technical review of The Gambia experience. *International Journal of Biological and Chemical Sciences*, *14*(3), 1093-1102.

Kikwai, C., & Ngeiywa, M. (2022). Review on the Socio-Economic Impacts of *trypanosomiasis*.

Karshima, S.N., Ajogi, I., Mohammed, G., 2016a. Eco-epidemiology of porcine *trypanosomosis* in Karim Lamido, Nigeria: prevalence, seasonal distribution, tsetse density and infection rates. Parasites & Vect. 9, 448.

Lema, A. A., Maigoro, M. A., Said, M., Marwana, A.M. and Nuraddeen, W. Prevalence of *bovine trypanasomosis* in Katsina Central Abattoir, Katsina State, pages 114-117

Mabille, D., & Caljon, G. (2020). Inflammation following trypanosome infection and persistence in the skin. *Current Opinion in Immunology*, *66*, 65-73.

Maichomo, M. W., Orenge, C. O., & Gamba, D. O. (2021). Introduction of African Animal Trypanosomosis (AAT)/Nagana. In *Combating and Controlling Nagana and Tick-Borne Diseases in Livestock* (pp. 1-23). IGI Global.

Megersa, B., Temesgen, W., Amenu, K., Asfaw, W., Gizaw, S., Yussuf, B., & Knight-Jones, T. J. (2024). Camels in Ethiopia: An overview of demography, productivity, socio-economic value and diseases.

Morrison, L. J., Steketee, P. C., Tettey, M. D., & Matthews, K. R. (2023). Pathogenicity and virulence of African trypanosomes: From laboratory models to clinically relevant hosts. *Virulence*, *14*(1), 2150445.

Nagel, P., & Peveling, R. (2021). Environment and the sterile insect technique. In *Sterile Insect Technique* (pp. 753-780). CRC Press.

Njom, V. S., Iyam, I. O., Awam, C. O., Ifeanyichukwu, O. C., & Obini, F. U. (2024). Assessment of the Socio-Economic Burden of *trypanosomiasis* Infection in Selected Tsetse Endemic Communities of Enugu South LGA. *Asian Journal of Advances in Research*, *7*(1), 508-517.

Odeniran, P. O. (2020). *Transmission patterns of trypanosomes in fly vector populations and bovine host in Southwestern Nigeria* (Doctoral dissertation).

Ogunrinde, A. O., *et al*. (2021). Prevalence of *trypanosomiasis* in Northern Nigeria: A Review of Recent Studies. Journal of Parasitology and Vector Biology, 14(1), 1-10.

Onyango, S. O., Mukoya-Wangia, S., Kinama, J. M., & Olet, P. A. (2020). Integration of Tsetse Fly and *trypanosomiasis* Control Methods from Livestock Farmers' Perspective: A Multivariate Probit Approach. *Journal of Agricultural Science*, *12*(10).

Opiro, R., Opoke, R., Angwech, H., Nakafu, E., Oloya, F. A., Openy, G., ... & Opiyo, E. A. (2021). Apparent density, trypanosome infection rates and host preference of tsetse flies in the sleeping sickness endemic focus of northwestern Uganda. *BMC Veterinary Research*, *17*, 1-12.

Orsborne, J. (2020). *Mosquito (Diptera: Culicidae) biting behaviour and malaria transmission: interactions between intrinsic host preferences and local host availability* (Doctoral dissertation, London School of Hygiene & Tropical Medicine).

ISSN (Print): 1597-7463; eISSN (Online): 2811-2598, Volume 6, Issue 1
https://dx.doi.org/10.4314/hpjsmt.v6i1.14
Rebuma, T., Regassa, M., Tariku, F., & Girma, W. (2024). Review on epidemiology and economic impact of tsetse transmitted Bovine *trypanosomiasis* in Ethiopia. *International Journal of Medical Parasitology and Epidemiology Sciences*, *5*(1), 24-30.

Sarwar, M. (2020). Typical flies: Natural history, lifestyle and diversity of Diptera. In *Life Cycle and Development of Diptera*. IntechOpen.

Sede Di Grosseto, S. E. (2022). Pathology/Biology_2022. *Meeeflng and Surpassing Th· E Challuenges of a 00 e m od 8 r n, fore n s· icscie n ce 1 world.*\, 737.

Shiferaw, M. T., & Unviresty, A. (2021). Assessment on The Effect of Delthamethrine 1% Pours on at Different Rigime In Control of Tsetse Fly and *Trypanosomosis* in two Distrect of Gamo Zone, Southern Ethiopia. *Gsj*, *9*(1).

Sikiru, A. B., Velayyudhan, S. M., Nair, M. R. R., Veerasamy, S., & Makinde, J. O. (2023). Sustaining livestock production under the changing climate: Africa scenario for Nigeria resilience and adaptation actions. In *Climate change impacts on Nigeria: Environment and sustainable development* (pp. 233-259). Cham: Springer International Publishing.

Steverding, D. (2020). The spreading of parasites by human migratory activities. *Virulence*, *11*(1), 1177-1191.

Takeet, M. I. (2015). Prevalence and Molecular Characterisation of Trypanosomes Of Cattle in Ogun and Kaduna States, Nigeria (Doctoral Dissertation).

Torka, T. T. (2023). Bovine Trypanosomosis and its Status in Ethiopia. *Int. J. Adv. Res. Biol. Sci*, *10*(11), 59-71.

Usman, A., Yusuf, A., Bakiyawa, A. T., Usman, A., Matazu, N. U., & Isah, M. B. (2024). Detection and Epidemiology of Trypanosome Infection in Livestock at Katsina Abattoir: Implications for Biosecurity and Animal Health in Northern Nigeria. *UMYU Scientifica*, *3*(4), 300-310.

Van Eenennaam, A. L., & Werth, S. J. (2021). Animal board invited review: animal agriculture and alternative meats–learning from past science communication failures. *Animal*, *15*(10), 100360.

Venturelli, A., Tagliazucchi, L., Lima, C., Venuti, F., Malpezzi, G., Magoulas, G. E., & Costi, M. P. (2022). Current treatments to control African *trypanosomiasis* and one health perspective. *Microorganisms*, *10*(7), 1298.

Wamwiri, F. N., & Auma, J. E. (2021). Overview of the Vectors and Their Role in Transmission of African Animal *trypanosomiasis*. In *Combating and Controlling Nagana and Tick-Borne Diseases in Livestock* (pp. 53-72). IGI Global.

Wayo B, Samdi SM, Fajinmi A.O. Prevalence of *trypanosomiasis* in sheep in the Kachia grazing reserve, Kachia, Kaduna State, Nigeria. African Journal of Clinical and Experimental Microbiology 2017. DOI: 10.4314/ajcem.v18i2.10.

Vadav, A. K., Verma, D., & Solanki, P. R. (2023). Introduction to numerous diseases of the livestock. In *Nanobiotechnology for the Livestock Industry* (pp. 141-156). Elsevier.