SPECIES

An update on tsé tsé flies and animal trypanosomiasis distribution and control in North Region of Cameroon: A scoping review

To Cite:
Achiri FM, Sevidzem SL, Nguema RM, Abah S, Bozdoğan H, Mavoungou JF. An update on tsé tsé flies and animal trypanosomiasis distribution and control in North Region of Cameroon: A scoping review. *Species* 2023; 24: e22s1021
doi: https://doi.org/10.54905/disssi/v24i73/e22s1021

Author Affiliation:
[1]Special Mission for Tse-tse fly Eradication (MSEG), Cameroon
[2]Université Libreville Nord, Laboratoire d'écologie des maladies transmissible (LEMAT), BP 1177, Libreville, Gabon
[3] Institut de Recherche en Ecologie tropicale (IRET/CENAREST), BP. 13354 Libreville, Gabon
[4]Kırşehir Ahi Evran University, Vocational School of Technical Sciences, Department of Plant and Animal Production, 40100, Kırşehir, Turkey

[*]**Corresponding author**
Université Libreville Nord, Laboratoire d'écologie des maladies transmissible (LEMAT), BP 1177, Libreville
Gabon
Email: sevidzem.lendze@gmail.com

Peer-Review History
Received: 09 December 2022
Reviewed & Revised: 12/December/2022 to 01/March/2023
Accepted: 02 March 2023
Published: 6 March 2023

Peer-Review Model
External peer-review was done through double-blind method.

Species
pISSN 2319–5746; eISSN 2319–5754

Fru Martin Achiri[1], **Silas Lendzele Sevidzem**[2*], **Rodrigue Mintsa Nguema**[2,3], **Samuel Abah**[1], **Hakan Bozdoğan**[4], **Jacques Francois Mavoungou**[3]

ABSTRACT

Tsé tsé-transmitted and non-tsé tsé transmitted animal trypanosomiasis remains a threat to the development of the livestock sector of Cameroon. A scoping review was conducted for the North region from 1960s till date to update on the following aspects of the disease and its vectors: i) Tsé tsé and animal trypanosomiasis (T&T) distribution, ii) History of Eradication Campaigns (ECs), iii) Evolution of control strategies, iv) Strategies for the conservation of previously cleared rangelands, v) Occurrence of mechanical vectors and vi) Perspectives for T & T control in the North. For the past more than half a decade of tsé tsé flies fight, *G. tachinoides* and *G. morsitans submorsitans* remains the only two main vector-species identified overlappingly infesting the area. Similarly, *T. congolense*, *T. brucei*, and *T. vivax* are the pathogenic species of trypanosomes infecting cattle since the year 1995. Apart from tsé tsé flies, other mechanical vectors such as tabanids and Stomoxys are wide spread and might be transmitting animal trypanosomiasis (AT) mechanically in tsé tsé free areas of the Northern region. The re-invasion of previously tsé tsé-cleared areas by infested areas (adjacent to the three national parks) that was signaled in 1976 is still a threat to the disease elimination. The fight against tsé tsé to stop the transmission of trypanosomiasis is still ongoing but operating at low levels at the barriers between infested and cleared areas as well as in pasture areas of the infested zones using an integrated approach involving Insecticide Treated Cattle (ITC), Insecticide treated Targets and Traps (ITTTs) and trypanocides. For the past years, the Special Mission for Tsé tsé Eradication (MSEG) has cleared up to 8 000 000 ha of pasture land in the Northern regions of Cameroon. Applying the African Animal Trypanosomiasis Progressive Control Pathway (AAT-PCP) protocol in Cameroon, the North region is in stage 1. Data on T&T for the North region remains scant and robust entomological, epidemiological, and economic impact data for this area is required to guide targeted control by the fly intervention authorities.

DISCOVERY SCIENTIFIC SOCIETY

Keywords: Tsé tsé, animal trypanosomiasis, distribution, eradication campaigns, North

1. INTRODUCTION

Tsé tsé flies are blood-sucking dipterids belonging to the genus *Glossina* and are biological vectors of a family of blood-dwelling parasites known as trypanosomes. Tsé tsé flies only occur in Africa and infest about 10 million km^2 of land. About 34 species and subspecies of this fly-group have already been documented (Hamon et al., 2021). Twelve different species of tse tse flies with heterogenous distribution have been reported to occur within the Cameroonian territory (Rageau and Adam, 1953) where they constitutes a major constraint to rural development and cattle production in particular. The three northern regions of Cameroon are among the four major cattle production areas of the country (Mamoudou and Sevidzem, 2017). In the past, the danger of the tsé tsé fly was well known by the populations of the Northern regions, both in terms of AT than human trypanosomiasis (HT). It was reported that there was a period where 75% of the major rangelands in the northern regions referred to as infested zones became unsuitable for breeding and for a region that essentially relies on animal husbandry, the intensification of research on the vectors and its control became a necessity. Dr Eugène Jamot in 1926 was the first to start the fight (Mouchet et al., 1961); subsequently, tsé tsé control operations started from 1967 to 1990s, with success, in North Cameroon (Ndoki et al., 1991). After the last ground spray eradications in 1990s, the special mission for tsé tsé control that was created in 1974 continued till date with control activities in the North, Far North and Adamawa regions.

Animal trypanosomiasis is a disease caused by haemoprotozoans of the genus *Trypanosoma* and is transmitted biologically by tsé tsé flies and mechanically by other biting flies such as *Hippobosca*, Stomoxys, *Haematopota*, *Tabanus*, *Pangonia*, *Chrysops*. It is ranked the number one important disease of cattle in terms of monetary losses (low meat and milk production and low draught power) in the North and Adamawa and is commonly caused by three pathogenic species (*T. congolense*, *T. brucei brucei* and *T. vivax*) (Ndamkou and Nchare, 1995; Achukwi and Musongong, 2009; Mamoudou et al., 2015a,b; Fauron et al., 2014; Mamoudou et al., 2016a; Mamoudou et al., 2017; Ngomtcho et al., 2017; Paguem et al., 2019). Over the past years, the MSEG supports farmers to treat trypanosomiasis cases in their farms but the coverage remains very low due to the limited budget. However, treatment is mostly conducted by farmers themselves and most of them have frequently reported treatment failure and attributed it to ineffective or fake drugs and resistance (Fauron et al., 2014).

In spite the successful suppression of tsetse flies between 1970s and 1990s that led to the clearing of up to 1 847 815 ha of pasture lands from it, the issue of persistent re-invasion of free zones by infested zones and neighbouring wildlife reserves maintained the occurrence of these important vectors in some rangelands of the North. The available entomological data between 1993 and 1994 from the MSEG division of Garoua showed the presence of *G. tachinoides* in Mayo Rey but the *Glossina* spp. caught around Bénoué was not identified (Nchare, 1994). In the Faro division, *G. tachinoides* and *G. morsitans submorsitans* were identified in Poli (Achukwi and Musongong, 2009). A longitudinal entomological survey from September 2011 to October 2013 in several villages within Mayo Rey division led to the identification of two *Glossina* spp. (*G. tachinoides* and *G. morsitans submorsitans*) whose populations were highly reduced using screens (Mamoudou et al., 2017). In 2014 in Gamba, *G. tachinoides* and *G. morsitans submorsitans* were caught in Gamba of the Faro division (Achiri, 2015; Ngomtcho et al., 2017). In this same year in Mayo Rey, Mamoudou et al., (2016) reported the presence of these two species.

In 2015 these two species were again identified in Sora Mboum village of Mayo Rey division (Sevidzem et al., 2016). According to the recent report of the MSEG, their control activities have led to the freing of upto 8 000 000 ha of pasture land from tsé tsé flies in the Northern regions of Cameroon (Abah, 2020). Applying the AAT-PCP in Cameroon, at the regional level, the North region is in stage 1, Adamawa is in stage 2 and the Far North region is in stage 3 (Abah, 2020). Although field entomological activities have been conducted in this region for the past > 60 years ago there is no updated open access scientific report on the occurrence and distribution of T&T as well as the progress in T&T control operations in the North region of Cameroon. The objectives of this study are : i) To update on T&T distribution, ii) To present the history of Eradication Campaigns (ECs), iii) To show the evolution of control strategies, iv) To present some strategies for the conservation of previously cleared rangelands, v) To present on the occurrence of mechanical vectors and vi) To present perspectives for T&T control in the North.

2. MATERIALS AND METHODS

Description of North Region

The North region is an excellent cattle production area of Cameroon that is found between latitudes 7^o 30′ to 13^o north and longitude 12^o and 16^o east and occupies a surface area of 100 353 km^2. It shares boundary to the west with Nigeria and the East with

Chad. Administratively, the North region is currently divided into four divisions namely: Faro, Bénoué, Mayo-Louti and Mayo-Rey (Figure 1). The indigenous population depends on agriculture (cultivation of sorghum, millet, cotton, groundnuts, rice, cassava and maize), fishing and animal rearing. The climate of this region is of the Sudano-sahelian type with annual precipitations of 400-900mm, rainy season from July to October and temperatures of 21° - 36°C. The vegetation of this region comprises woody savanna and some gallery forests. The hydrological network is made of the following rivers- Chari, Logone, Bénoué, Mayo-Kebbi and Faro. The north region host three national parks notably: Bouba-ndjiddah park (2203 km^2), Bénoué park (2305 km^2) and Faro Park (3740 km^2). To facilitate the monitoring of the control activities by the MSEG, the Northern region was segmented into two parts with the Northern part (Mayo Louti and North Bénoué) considered tsé tsé free due to the absence of tsé tsé and the Southern part (Faro and Mayo Rey) harboured high populations of tsé tsé and represented the infested zone (Gruvel, 1979; Achiri, 2015, 2016, 2018).

Figure 1 Map of North region showing the four main administrative divisions

Information sources and criteria for selection

A scoping review was conducted following standard guidelines (Munn et al., 2018). Information was gotten form the available annual reports of the MSEG North and Far North division. Other reports from FAO, IAEA, LANAVET, on tsé tsé were considered. Also, peer-reviewed papers were obtained via online search by using the following keywords: « Bénoué », « North », « tsé tsé », «glossines », « eradication campaigns », « animal trypanosomiasis », « tsé tsé fight », « tsé tsé control » and « tse tse ». The search was from electronic scholarly databases such as MEDLINE (PubMed), Scopus (Elsevier), ScienceDirect (Elsevier), Web of Science (WoS), African Journal Online (AJOL) and SciELO (Web of Science). The sources for unpublished studies included bioRxiv (preprints), medRxiv (preprints) and SSRN (preprints). The inclusion criteria were only documents on the subject within the stipulated time frame in the North. However, documents on the topic from other regions and neighbouring countries were only used for discussion of findings. Data identification, screening and inclusion were conducted using the updated PRISMA protocol from Page et al., (2021). By applying the inclusion criteria, a total of 32 relevant records were retained and used in this study (Figure 2; Appendix 1).

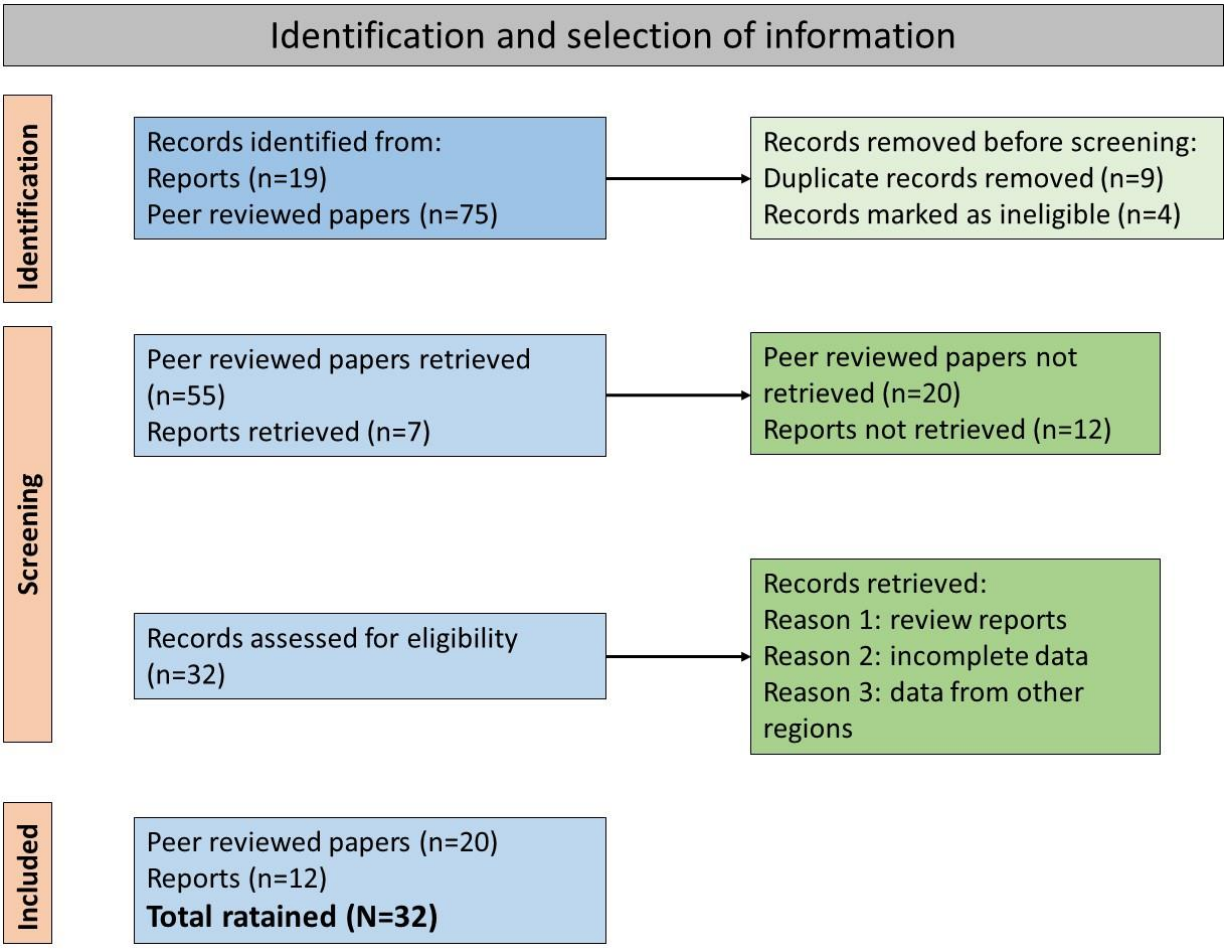

Figure 2 Flow chart showing data identification, screening and inclusion using the PRISMA protocol (Page et al., 2021)

3. RESULTS

An update on tsé tsé occurrence

In 1937, *G. morsitans submorsitans* was reported in the Centre-North region of Cameroon (Gruvel et al., 1970a, b). The distribution map of tsé tsé in Cameroon published in 1951 indicated the widespread of *G. morsitans submorsitans* and *G. tachinoides* in the North region (Rageau and Adam, 1951). In 1967 during the experimental eradication campaign organised by Cameroon on the 15th of February 1967 in Mayo-kebbi, 50 tsé tsé were collected and were all *G. tachinoides*. In 1972, during the preparation of the Lake Chad Basin campaign, a single species of tsetse flies (*G. tachinoides*) infested the northern region. While to the south, on the Mayo-Tiel to the north from Garoua, from Demsa to Diatoumi and on the Mayo-Tsikakiri at Belel and Ouro Bayoua, *G. morsitans submorsitans* was encountered. South of Garoua, on the Bénoué, the gallery forests were infested with *G. tachinoides*, except in the Ouro Ardo Rey village where *G. morsitans submorsitans* was encountered. To the east of Garoua, on the Bénoué and the entire Mayo Kebbi, from its mouth to Lake Léré, *G. tachinoides* was found. From Garoua southwards to the 8th parallel, the two species of tsé tsé flies (*G. morsitans submorsitans* and *G. tachinoides*) were encountered.

The creation in 1974 of the MSEG specialized in the organization of entomological prospection campaigns, control campaigns against tsé tsé and conservation operations in the free areas made it possible to rapidly improve knowledge on the distribution of tsetse flies in north Cameroon and to identify the different ecosystems favorable to the predominant tsetse species (*G. morsitans submorsitans* and *G. tachinoides*). In April 1994, *G. tachinoides* was encountered in Mayo Rey division precisely along Mayo-Rey, Mayo-Louga, Ria and Windé-Ria (Nchare, 1994). In May 1994, unknown species of *Glossina* were collected in Bénoué precisely around Touroua, Boronga-Koléré, Lafiari and Djaouro-Tagou (Nchare, 1994). In 2009 in Poli of the Faro division, the two species (*G. morsitans submorsitans* and *G. tachinoides*) were trapped (Achukwi and Musongong, 2009). From 2011 to 2018 in Mayo-Rey, these two species were widespread in this division (Achiri, 2015; Achiri, 2016; Mamoudou et al., 2016; Sevidzem et al., 2016; Mamoudou et al., 2017; Achiri, 2018). In Gamba area, in 2014, these two species were trapped (Achiri, 2015; Ngomtcho et al., 2017). Thus, it could be

concluded that *G. tachinoides* and *G. morsitans submorsitans* are the only tsé tsé species existing in North Cameroon located beyond the 8th degree north (Figure 3).

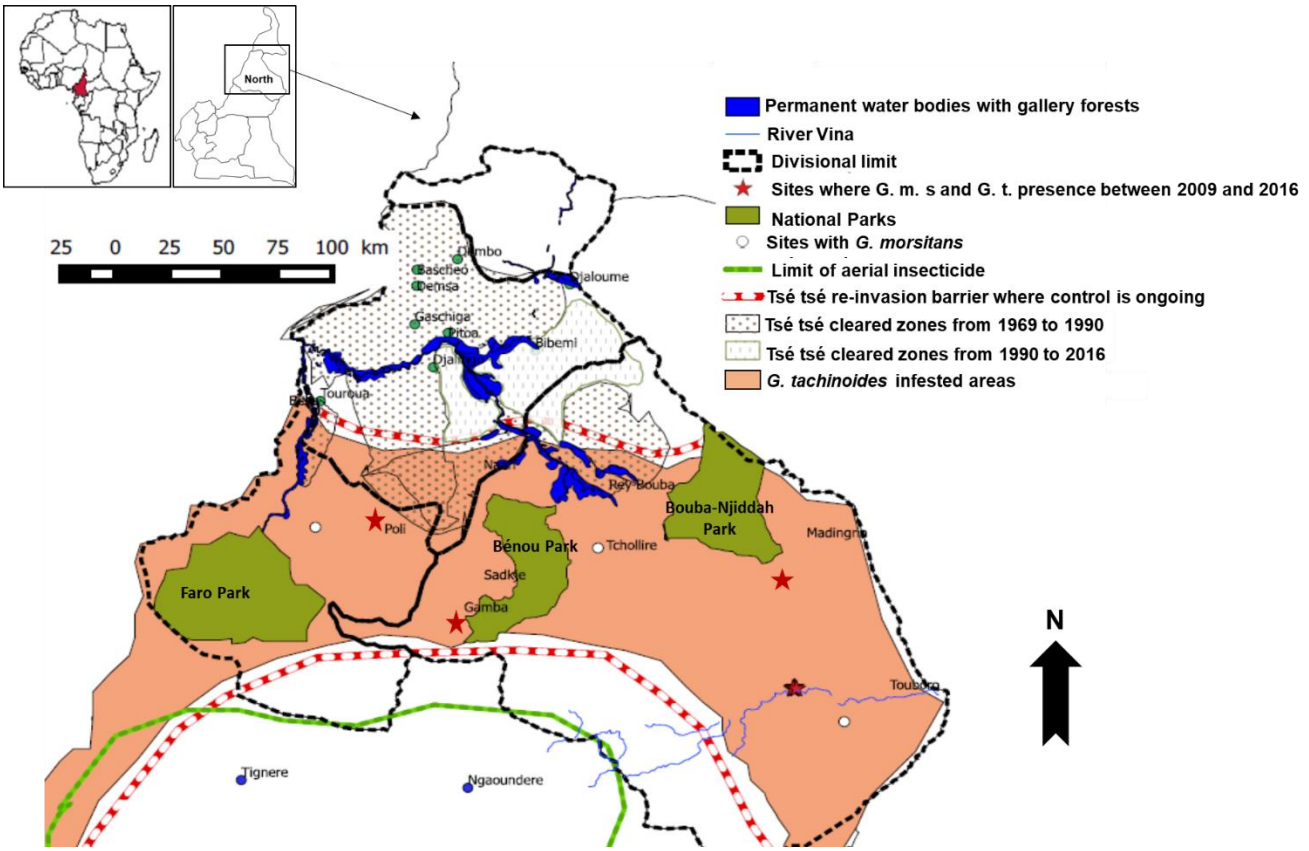

Figure 3 An updated map of tsé tsé belts and key dates on its control in the North region of Cameroon G.m.s: *Glossina morsitans submorsitans*; G.t: *Glossina tachinoides*

An update on AT occurrence

Animal trypanosomiasis (AT) was reported to cause high morbidities, mortalities and abortions in cattle in the North region and high burden of this disease was felt by poor farmers in the infested southern part of the region. Between 1973 and 1977 the mortality rates of infected animals ranged from 23 to 40% (Gruvel, 1979). During this period, about 94 212 animals received free treatment in the infested and free areas of the region. The first region-wide screening of cattle for AT was conducted in all the four divisions from 1994 to 1995 through the joint FAO/IAEA project. This study led to the sampling of 2959 cattle herds and *T. vivax*, *T. congolense* and *T. brucei* were confirmed via buffy coat technique (BCT) to be present in all the four divisions at prevalence rates between 0.98 to 4.03% (Ndamkou and Nchare, 1995). In 2009, these three *Trypanosoma* spp. and their co-infections were again confirmed via BCT in 17 villages in the Faro division (Achukwi and Musongong, 2009).

In 2014, cattle from several villages in the Mayo-Rey division were sampled and all the three species were still detected (BCT+PCR) with their mixed infections (Mamoudou et al., 2015a, b, 2016, 2017; Paguem et al., 2019), but of interest was the detection (PCR) of *T. theileri* in cattle for the first time in Cameroon (Ngomtcho et al., 2017). From the report of Ngomtcho et al., (2019), *G. morsitans submorsitans* (*T. grayi*, *T. congolense* and *T. brucei* spp.) and *G. tachinoides* (*T. grayi* and *T. brucei* spp.) were differentially infected with *Trypanosoma* spp. (Figure 4). Although the efficacy of two formulations of Isometamidium has already been tested in the North (Awa and Ndamkou, 2006), no study has been conducted to identify trypanoresistance to trypanocides in local cattle populations of this region that are frequently treated with trypanocides (Fauron et al., 2014). Another gap in AT research is that the role of domesticated animals in its epizootiology has not yet been examined.

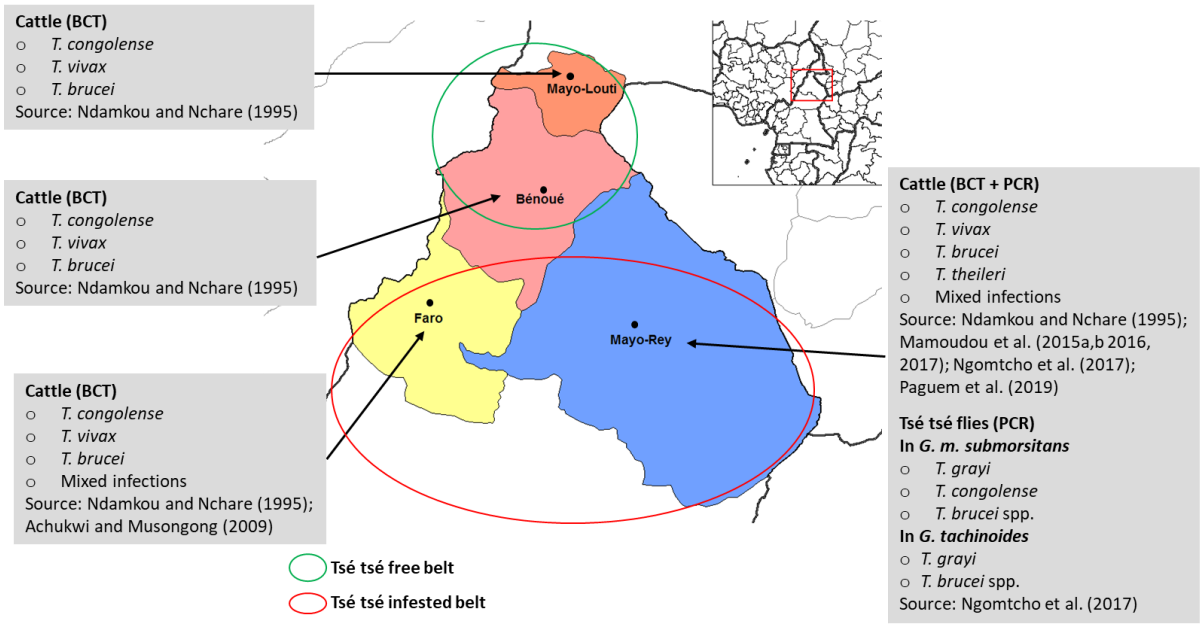

Figure 4 An updated distribution map of *Trypanosoma* spp. in North region

Tsetse eradication campaigns

Due to the economic impact of tsé tsé in key cattle production regions of Cameroon such as the Northern regions, successive eradication campaigns were organised from 1960s to 1990s to eliminate these fly-vectors, with objective to increase pasture lands inorder to obtain high numbers and healthy herds in such affected areas (Nchare, 1994). The ECs in the North region consisted of an experimental phase to elimate *Glossina tachinoides* in the gallery forests of the Mayo-Kebbi valley till Djaloumi, followed by six joint eradication campaigns with neigbouring Nigeria/Chad from 1970 to 1976 following the bilateral agreement during the 11th meeting of the commission of the Lake Chad Basin held at Niamey in Niger from 22 to 27 June 1970 and lastly by regional ground spray campaigns (1977 to 1990) by the tsetse eradication unit (MSEG) for North and Extreme North. In April 1976, Dr R Tibayrenc reported the absence of tsé tsé flies in south Bénoué. But two important periods (1968-1969 and 1969-1970) marked the re-invasion of the formerly cleared Mayo kebbi zone by the rupture of the Babla barrier and influx of animals from infested areas as reported by Dr R Tibayrenc in 1976. From 1993 to date, the MSEG North and the Far North division continues with low control activities in the Mayo-Rey, Faro and Bénoué divisions which have been reported to harbor high populations of tsé tsé flies (Figure 5).

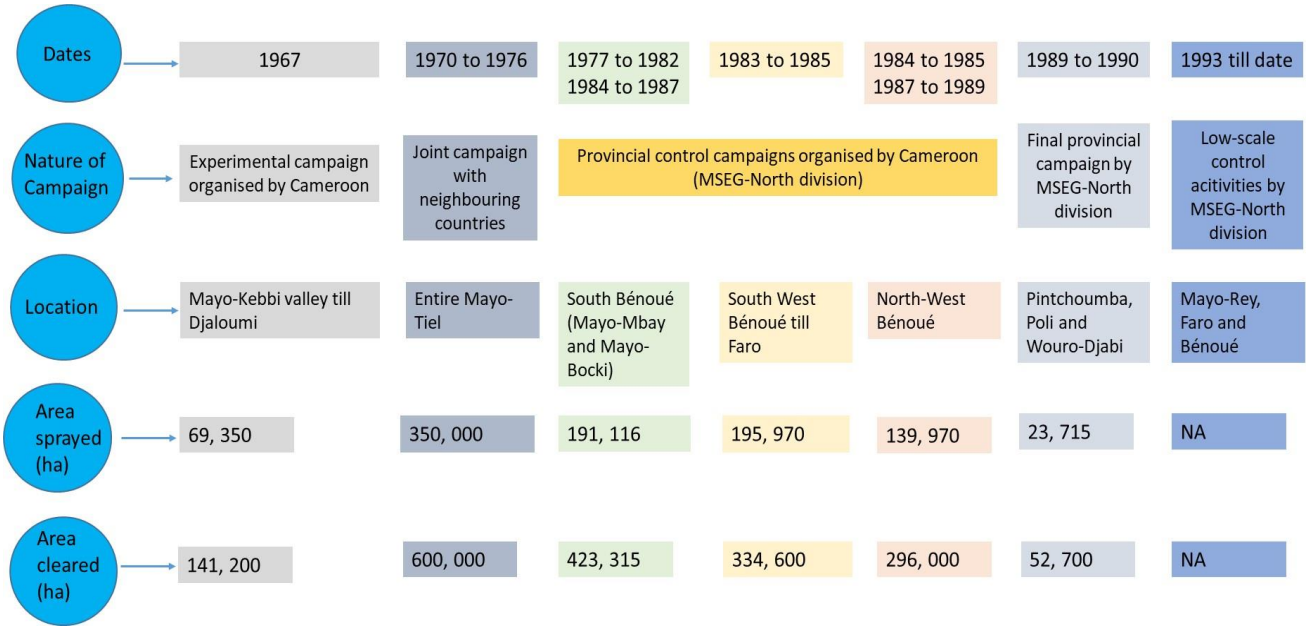

Figure 5 Periodic scale of major tsé tsé eradication campaigns in North Cameroon NA: Not Available

Evolution in control methods against T & T

The special mission for tsé tsé eradication (MSEG) is a Government structure that was created in 1974 to fight against tsé tsé flies. The MSEG with head office in Ngaoundere town, for ease of execution of its activities, two divisions were created, the Adamawa division to lead control activities in the Adamawa region and the North and Far North division to head control activities in the North and Far North regions. The experimental eradication campaign was conducted by spraying tsé tsé resting areas around the gallery forest along the Mayo-Kebbi using dichlorodiphenyltrichloroethane (DDT) as well as clearing that vegetation that served as breeding grounds for this fly-vector. This method was effective as livestock keepers and fishers confirmed the absence of tsé tsé in their area (Gruvel et al., 1970a, b). Similarly, during the joint eradication campaigns with neigbouring countries (Nigeria and Chad) from 1970 to 1976, the same control methods were used, but for the fact that DDT was used together with Dieldrine (Bakary, 1975) (Table 1). The control operations by the MSEG North and Far North divison in the 1990s added insecticide impregnated screens to their control tool box. Between 1992 and 1993, the re-invasion barrier was reinforced with more than 860 screens but > 600 of them were stolen and/or destroyed by bush fires (Nchare, 1994). After the seminar FAO-TCP/CMR/0051 held in 1991 in the North region on the new control techniques against tsé tsé flies, several livestock keepers appreciated the Pour-On approach because it was easy to use. Progressively, the MSEG added more control methods such as the ZeroFly® fence and the use of pyrethroids and organophosphorus insecticides for spraying cattle as well as for treating traps and targets (Achiri, 2015, 2016, 2018) (Figure 6). Although ZeroFly® is an expensive but effective method, it is suitable for feedlots or intensive breeding systems.

Figure 6 Methods used by the MSEG to control fly-vectors from 1990s till date. A) animal spray; B) Pour-On application; C) Insecticide treated traps; D) Insecticide treated screens; E) ZeroFly®.

Animal trypanosomiasis continues to cause huge economic losses to the animal industry of Cameroon where 39% of the animals are at risk of infection, prevalence is estimated at 15%, productivity loss for milk (26%) and Milk (30%) and yearly expenditure for control is estimated at 166 000 dollars (Abro et al., 2021). The control of T&T in Cameroon include the extensive use of insecticides by farmers and low control activities conducted by the MSEG. The strategy developed after the pilot eradication campaign was to strengthen and/or maintain the natural re-invasion barriers using insecticides. For this, the MSEG set insecticide treated traps and screens at the different re-invasion fronts and these are usually supplemented with the prophylactic trypanocide treatment of transhumant cattle moving between tsé tsé free and infested areas (Meyer et al., 2018). Although a report on the existing techniques used for tsé tsé control in Cameroon by Meyer et al., (2016) indicates that since 1980 insecticide treated cattle (ITC), Insecticide Treated Targets and Traps (ITTTs) and Sequential Aerial Spraying (SAS) are being applied in the country, it is important to note that the SAS was used in the Adamawa Plateau and only ground spraying was practiced in the North (Gruvel, 1979). The identification of AT cases in cattle is based on some symptoms such as lacrimation, drowling and emaciation as well as use of

parasitological tests (microscopy). From 1973 to 1977, AT cases identified in some cattle farms in the North and South of the North region were treated freely with Isometamidium000 (N.D Trypamidium) and Diminazene (ND Berenil) eventhough the coverage was very low due to the lack of products. Two formulations of Isometamidium were tested on zebu cattle challenged with *T. vivax* and *T. congolense* from 2000 to 2001 and a similar outcome was noticed for both formulations (Awa and Ndamkou, 2006). Although the persistent detection of trypanosomes in Cameroonian ruminants populations in tsé tsé infested areas has been linked to the possibility of trypanoresistance to the available trypanocide molecules (Simo et al., 2020), no such data is available for the North region.

Table 1 Evolution in T & T control methods in the North region

Date	Tsé tsé	Animal Trypanosomiasis	References
1967	-Clearing of tsé tsé resting sites -Ground spraying (DDT only)	Not available	Fernagut, (1967)
1970 to 1976	-Clearing of tsé tsé resting sites -Ground spraying (DDT and Dieldrine)	Use of trypanocides: Prophylaxis: Isometamidium Curative: Diminazene	Gruvel, (1979) Bakary, (1975) Bakary, (1976)
1977 to 1987	-Clearing of tsé tsé resting sites -Ground spraying (DDT and Dieldrine)	Use of trypanocides: Prophylaxis: Isometamidium Curative: Diminazene	Ndoki et al., (1991)
1987 to 1989	-Clearing of tsé tsé resting sites -Ground spraying (DDT and Dieldrine)	Use of trypanocides: Prophylaxis: Isometamidium Curative: Diminazene	Ndoki et al., (1991)
1989 to 1990	-Clearing of tsé tsé resting sites -Ground spraying (DDT and Dieldrine)	Use of trypanocides: Prophylaxis: Isometamidium Curative: Diminazene	Ndoki et al., (1991)
1993 to 1994	-Clearing of tsé tsé resting sites -Ground spraying (K. Othrine and Dieldrine) -Insecticide treated catttle (Pour-On, Spraying, insecticide baths) -Insecticide treated targets	Use of trypanocides: Prophylaxis: Isometamidium Curative: Diminazene	Nchare, (1994)
2000 till date	*Insecticides used here include : pyrethroids and organophosphorus -Insecticide treated catttle (Pour-On, Spraying, insecticide baths) -Insecticide treated traps -Insecticide treated targets	Use of trypanocides: Prophylaxis: Isometamidium Curative: Diminazene	Awa and Ndamkou, (2006) Fauron et al., (2014) Achiri, (2015) Achiri, (2016) Achiri, (2018) Meyer et al., (2016) Mamoudou et al., (2017) Meyer et al., (2018) Sevidzem et al., (2022a)

Strategies for the conservation of tsé tsé free rangelands

The occurrence of three major national parks in the north region such as the Faro, Bénoué and Bouba-Ndjiddah has raised the hypothesis that these reserves act as tsé tsé re-invasion sources because they habour high diversity of vertebrate hosts for flies and control activities do not occur there. In the past, in the North region, fly control authorities identified a natural barrier known as the Babla barrier to prevent re-invasion of formerly cleared territories (Bakary, 1976). Today, such delimitations that indicates tsetse free belts and infested belts still occur. To conserve major rangelands of the tsé tsé free North from re-invasion by tsetse infested south, the following has to be strictly followed: 1) Regular trapping activities to map-out tsé tsé presence areas as well as systematic sampling of animals to check for AT infectons; 2) Sensitisation of livestock keepers on the importance of maintaining pasture areas free of tsé tsé and to show the economic relevance (reduction in animal mortality rate, reduction in treatment costs and live weight gains) of doing so; 3) Organise community training of rural pastoralists on the easy-to-use and cheap control methods; 4) Farmers should contribute in treatment costs since government subventions for the acquisition of insecticides and trypanocides is usually

insufficient; 5) The movement of animals between infested and non-infested zones as this is commonly observed during transhumance should be controlled.

Therefore, animals that go for transhumance must be subjected to the following conditions: i) The ITC must be applied upon departure and return from transhumance and ii) Conduct prophylactic and curative treatment of animals to stop transmission; 6) Since the North region shares boundaries with Chad and Nigeria and trade/transhumant animal movement between these countries is common, veterinary checkpoints should be reinforced to avoid the introduction of trypanosomes and other transboundary animal diseases such as FMD into the region; and 7) Joint or regional control projects aiming at eliminating the disease between Cameroon and neighbouring countries should be encouraged. For the past half a decade, through the support of the Cameroonian Government, the MSEG has been putting much effort to maintain previously free areas tsé tsé free and assisting farmers to conduct such activities in different communities. Today, it has been reported that more than 8,000,000 ha of excellent pasture have been cleared of tsé tsé in the Northern regions of Cameroon (Abah, 2020). Consequently, the integral control of the tsé tsé in North Cameroon must be encouraged.

Mechanical vectors of AT

The role of vectors such as tabanids and Stomoxys in the mechanical transmission of AT has already been hypothesized for the North region of Cameroon by Gruvel, (1979). The reports of the MSEG - North/Far North division from 2014 to 2018 indicates high abundance of tabanids and Stomoxys in some villages of the region where no tsé tsé have been caught (Mamoudou et al., 2016b, Lendzele et al., 2017; Achiri, 2018; Sevidzem et al., 2021; Sevidzem et al., 2022b). Even before then, Achukwi and Musongong, (2009) have already reported the occurrence of these mechanical vectors in the Faro division. A study reported that the Stomoxys fauna of the North region is composed of four species namel: *S. calcitrans*, *S. niger niger*, *S. niger bilineatus* and *S. sitiens* (Sevidzem et al., 2016). Another study reported that the *tabanidae* fauna of the North region consisted of six species notably: *T. gratus*, *T. par*, *T. taeniola*, *T. biguttatus*, *T. sufis* and *C. distinctipennis* (Lendzele et al., 2017). In the tsé tsé free Ngaoundere pasture area of the Adamawa highland, tabanids have already been identified to harbour trypanosomes similar to those detected in cattle (Sevidzem et al., 2022b). Because of the high abundance of these mechanical vectors in rangelands of the Northern regions, the MSEG has included them in its intervention programs.

Perspectives for T & T control in the North

The MSEG is the only national government structure that is involved in regular T & T control activities. For the past more than half a century, they have been focusing control in Northern regions that constitutes major cattle rearing areas of Cameroon (3) (Sevidzem and Mamoudou, 2017). With the persistently rising national and international demands for meat and animal products, Cameroon as the major supplier in the Central African sub-region intends to increase tsé tsé free rangelands in the North as well as in the South parts of the national territory. Although low interventions by the MSEG are underways in the three Northern regions via Government support, the budget is not sufficient to conduct large-scale interventions. Of recent, the Government of Cameroon through MINEPIA offered the MSEG a new edifice that has been functional since 2019. The building can host parasitological, entomological and molecular labs, cartography department, offices, meeting rooms and a conference hall. For now, there are equipment for parasitological and entomological studies but the molecular lab has not yet been equipped. In recent years the Government has stepped up the number of personnel (veterinary doctors, technicians and nurses) to boost its capacity.

The MSEG through its PATTEC partnership is currently a member of the COMBAT (controlling and progressively minimizing the burden of animal trypanosomiasis) launched in 20221 and involves 21 African countries (Boulangé et al., 2022), will assist the structure in the following ways: i) To develop and test the efficacy of novel environmentally friendly, cheap, available and easy-to-use diagnostic and control tools for T & T that are adapted to the different settings; ii) Improve epidemiological surveillance (provision of equipment for the molecular lab, support field data collection in different regions of Cameroon and support national and international training of staff); iii) Developed a national atlas on T & T; and iv) Support the development of the national T & T strategic control plan. All the objectives of COMBAT fit perfectly with the strategy of the MSEG to successfully eliminate T & T from Cameroon in the nearest future. However, there is a need to consider the following in future studies on the topic in the Northern region: 1) AT in other domesticated animals besides cattle should be studied, 2) The role of mechanical vectors in the epizootiology of AT should be carefully examined, 3) Economic impact studies of T & T to farmers should be evaluated, 4) The role of mobile herds (transhumance and trade animals) in the spread of AT should be modeled, 5) Trypanoresistance to trypanocides in local ruminant species populations should be evaluated and 6) Trypanotolerant genes should be checked in local breeds of the North.

4. CONCLUSION

For the past more than half a decade, tsé tsé (*G. tachinoides* and *G. morsitans submorsitans*) still occurs in the infested southern parts of the North region where animal trypanosomiasis have been reported to be mainly caused by *T. congolense*, *T. vivax* and *T. brucei*. Large scale eradication campaigns in the past have now been replaced by low interventions by the MSEG which is currently focusing its activity in the infested southern region. Re-invasion of previously cleared areas by infested zones and transhumant animals remains problematic. Besides tsé tsé, mechanical vectors such as tabanids and Stomoxys are abundant and widespread in the entire region. Field entomological prospections, animal trypanosomiasis diagnostic capacity and treatment coverage with trypanocides remains very low in the region. Updated information on the free versus invaded/re-invaded rangelands in the North and South zones of the region is lacking. Similarly, there is no information on the economic impact of the disease to indicate farmers and Government priorities for T & T control.

List of abbreviations

AT: Animal Trypanosomiasis; BCT: Buffy Coat Technique; COMBAT: Controlling and Progressively Minimizing the Burden of Animal Trypanosomiasis; FAO: Food and Agricultural Organisation; IAEA: International Atomic Energy Agency; LANAVET: National Veterinary Laboratory; MINEPIA: Ministry of Livestock Fisheries and Animal Industries; MSEG: Special Mission for Tsé tsé Eradication; PATTEC: Pan African Tsé tsé and Trypanosomiasis Eradication Campaign; PCP: Progressive Control Pathway; PCR: Polymerase Chain Reaction; T & T: Tsé tsé and animal trypanosomiasis.

Acknowledgements

Authors are grateful to the staff of MSEG for accepting to participate in the study and for correcting the final draft of the manuscript.

Author's contribution

SLS and FMA participated in the conception of the study. SLS and FMA conducted literature search and selection of relevant documents used in the study. SLS and HB wrote the first draft. All authors (SLS, FMA, RMN, SA, HB, JFM) revised and approved the manuscript for publication.

Informed consent

Not applicable.

Ethical approval & declaration

In this review article, the authors documented the tsé tsé (*G. tachinoides* and *G. morsitans submorsitans*) flies & animal trypanosomiasis caused by *T. congolense*, *T. vivax* and *T. brucei*. The Animal ethical guidelines are followed in the study for species observation.

Conflicts of interests

The authors declare that there are no conflicts of interests.

Funding

The study has not received any external funding.

Data and materials availability

All data associated with this study are present in the paper.

Appendix 1 Information on the selected documents of this study.

Author (s) (Year) in alphabetical order	Title	Aims/objectives	Key findings
Abah, (2020)	Tsé tsé control activities in Cameroon since	To present the control activities of the MSEG since	The vector control activities consisted of the installation of 4250 screens in animal trypanosomosis risk areas; 2000 meters of ZeroFly® were installed in 18 cattle farms and 500 000 cattle

	November 2018	2018	were treated with insecticides. These activities controlled about 8 000 000 ha of rangeland. As part of the Progressive Control Pathway for AAT, Cameroon is at step 1, but Adamawa and North are both in step 2 and far north in step 3
Abro et al., (2021)	The potential economic benefits of controlling trypanosomiasis using waterbuck repellent blend in sub-Saharan Africa	To estimate the potential economic gains from adopting Waterbuck Repellent Blend (WRB)	This study found that the adoption of WRB in 5 to 50% of the animal population would generate an economic surplus of US$ 78–869 million per annum for African 18 countries. The estimated benefit-cost ratio (9 :1) further justifies an investment in WRB
Achiri, (2015)	Annual report of Special Mission for Tsé tsé Eradication (MSEG) from 2014 to 2015	To identify tsetse flies and other biting flies in Far North.	Mechanical vectors such as tabanids and Stomoxys are widespread and abundant in the absence of tsé tsé flies. In this area, 550m ZeroFly ® was set, 18 screens set, 17553 and 3135 cattle received epicutaneous insecticidal spray and Pour-On respectively, and 2670 heads of cattle were treated with trypanocides
Achiri, (2016)	Annual report of Special Mission for Tsé tsé Eradication (MSEG) from 2015 to 2016	To identify tsetse flies and other biting flies in Mayo Rey, sensitise cattle owners, conduct epicutaneous treatment of cattle with insecticides and treat them using trypanocides.	Tsetse was wide spread in the area and other biting flies such as tabanids and stomoxys were identified with high abundances. About 11353 and 3135 cattle were sprayed and Pour-On applied respectively
Achiri, (2018)	Le Rapport de la Division Tse-Tse Nord et L'Extreme Nord Premier Semestre 2018	To identify tsetse flies and other biting flies in North and Extreme North regions as well as to sensitise farmers	In Gamba and some sites of the Extreme North, no glossines were caught but mechanical vectors such as *tabanids* and Stomoxys were abundant. The sensitisation of 122 livestock keepers was conducted
Achukwi and Musongong, (2009)	Trypanosomosis in the Doayo/Namchi (Bos taurus) and zebu white Fulani (Bos indicus) cattle in Faro division, North Cameroon	To determine infection rates and assess the impact of trypanosomosis on livestock production in Cameroon	The study detected a significant carrier status of trypanosomosis in the Doayo cattle, which constitutes an important epizootiological risk for the more susceptible zebu type cattle and other animal species. For the entomological study, *G. morsitans submorsitans* and *G. tachinoides* as well as tabanids and Stomoxys were identified in Poli
Awa and Ndamkou, (2006)	Response of *T. vivax* and *T. congolense* in Zebu cattle in North Cameroon to prophylactic	To determine the efficacy of two formulations of Isometamidium	The efficacy was similar for the two formulations but animals were still detected with trypanosomes two weeks post treatment

	treatment with two formulations of Isometamidium		
Bakary, (1975)	An account of the execution of the 5th Joint Campaign 1974/1975 against glossines at the border between Cameroon and Nigeria	To spray gallery valleys from Bénoué to the confluent of Faro	14 400 ha of land were cleared of tsé tsé flies
Bakary, (1976)	Joint campaign from 1975 to 1976 against glossines at the border between Cameroon and Nigeria. Report of anti-glossine fight campaign of Benoue	To kill tsé tsé flies, major vectors of animal trypanosomiasis in order to increase better rangelands	No tsé tsé flies were caught post spray and this was confirmed by herders too
Boulangé et al., (2022)	The COMBAT project: Controlling and progressively minimizing the burden of vector-borne animal trypanosomosis in Africa	The project builds on the progressive control pathway (PCP), a risk-based, step-wise approach to disease reduction or elimination	« The COMBAT will strengthen AT control and prevention by improving basic knowledge of AT, developing innovative control tools, reinforcing surveillance, rationalizing control strategies, building capacity and raising awareness. Knowledge gaps on disease epidemiology, vector ecology and competence, and biological aspects of trypanotolerant livestock will be addressed. Environmentally friendly vector control technologies and more effective and adapted diagnostic tools will be developed. Surveillance will be enhanced by developing information systems, strengthening reporting, and mapping and modelling disease risk in Africa and beyond. The socio-economic burden of AT will be assessed at a range of geographical scales »
Fauron et al., (2014)	Baseline study for the integration of novel treatments, vaccines and diagnostics into Animal African Trypanosomosis control programmes: Cameroon Field Study Report	To assess the current perceived impact of AAT in the selected study areas and the scope for improving AAT control by introducing or integrating new control measures into future or existing AAT control programs	Animal trypanosomiasis is the number one important disease of cattle in terms of monetary losses in the North and Adamawa and is caused by three common pathogenic species (*T. congolense*, *T. brucei brucei* and *T. vivax*). Treatment failure was frequent and farmers attributed it to ineffective or fake drugs and resistance. However, most farmers are willing to use new diagnostic and treatment approaches.
Fernagut, (1967)	Execution of an experimental	To conduct a small-scale tsé tsé flies	10, 000 ha of rangeland recovered after tsé tsé flies clearance.

	campaign against glossiness in the Garoua Region	eradication campaign from Bénoué to Mayo Kebbi	
Gruvel, (1979)	Établissement de la division d'éradication des glossines de la Bénoué Cameroun). Rapport technique: Lutte contre les trypanosomoses	To evaluate the prevalence of glossiness and animal trypanosomiasis in the Bénoué division, to evaluate the herd exposure risk to animal trypanosomiasis infection, to study the systems of treatment, to examine the system of fight against glossiness in the area and to elaborate the glossiness control program.	High animal trypanosomiasis prevalence was obtained in the Southern Bénoué compared to that of its Northern counterpart. The tsé tsé distribution maps were updated by indicating the limits of tsé tsé cleared and infested areas for *G. morsitans submorsitans* and *G. tachinoides*.
Lendzele et al., (2017)	Spatial repartition of tabanids (Diptera: *Tabanidae*) in different ecological zones of North Cameroon	To characterise the species of tabanids and determine their abundance with landscape	Six species of tabanids were identified: *Tabanus gratus*, *Chrysops distinctipennis*, *T. taeniola*, *T. biguttatus*, *T. sufis* and *T. par*. The six species identified were common in all the three ecozones
Mamoudou and Sevidzem, (2017)	Bovine trypanosomiasis prevalence and its major vector density in the major cattle rearing regions of Cameroon (Extreme North, North, Adamawa and North West): Past, Current and Future	To update on the situation of animal trypanosomiasis and its vectors in the major cattle production areas of Cameroon.	High prevalence of animal trypanosomiasis was determined in the North region precisely Mayo Rey division with high population of tsé tsé and tabanids.
Mamoudou et al., (2016b)	Tabanids (Diptera: Tabanidae) fauna composition in	To determine the abundance of tabanids and	The rangelands were hyper-infested with tabanids and were observed biting diversed vertebrate hosts.

	different sites and biotopes of Far-North, Cameroon	observe its host range	
Mamoudou et al., (2016a)	Animal trypanosomosis in clinically healthy cattle of North Cameroon: Epidemiological implications	To determine the prevalence of animal trypanosomiasis in subclinical cattle and evaluate the density of vectors	High prevalence occurred in subclinical animals. High densities of glossiness and tabanids were obtained.
Mamoudou et al., (2017)	Evaluation of efficacy of Deltamethrin 10%-impregnated screens in a tsetse endemic area in the Sudano-Sahelian region of Cameroon	To determine the efficacy of screens in the control of tsé tsé flies and animal trypanosomiasis in the North	The screens cleared tsetse infestation and reduced trypanosomosis incidence, as well as improved host health and reduced related risk factors in the area
Mamoudou et al., (2015a)	Prevalence and impact of bovine trypanosomiasis in Mayo Rey division, a Soudano-Sahelian zone of Cameroon	To determine the prevalence of bovine trypanosomiasis and its impact on production.	Animal trypanosomiasis was caused by three *Trypanosoma* spp. notably *T. congolense*, *T. brucei brucei* and *T. vivax*. Its impact in terms of weight loss was felt in the rainy season only.
Mamoudou et al., (2015b)	Trypanosomes and helminths infections in Mayo Rey Division of Cameroon and impact of concurrent infections on cattle	To determine the prevalence of coinfections with trypanosomes and helminths	High frequency of co-infections was obtained and had a negative impact on body condition and PCV of the sick animals.
Meyer et al., (2018)	Integrated cost-benefit analysis of tsetse control and herd productivity to inform control programs for animal African trypanosomiasis	To evaluate the benefits of tsetse control in Africa.	This study found that the elimination of tsetse populations from Faro et Déo will bring overall economic benefits for cattle farmers in these areas.
Meyer et al., (2016)	Past and Ongoing Tsetse and Animal Trypanosomiasis Control Operations	To review available information on present and past control	There was lack of evaluation of the control programmes, as well as lack of a standardised methodology to conduct such evaluations.

	in Five African Countries: A Systematic Review	programmes targeting animal trypanosomiasis and its vector, supplemented with interviews with key informants.	
Nchare, (1994)	Annual report of Special Mission for Tsé tsé Eradication (MSEG) from 1993 to 1994.	To update on the current situation of animal trypanosomiasis and its vectors in the North	The lack of budget since 1991 affected the activities of the MSEG- North and Far North divison. However, high mortalities of animals caused by animal trypanosomiasis were registered in the tsé tsé re-invaded areas.
Ndamkou and Nchare, (1995)	Bovine trypanosomiasis in North Province of Cameroon	To evaluate the prevalence of bovine trypanosomiasis in all the divisions of the North region	Animal trypanosomiasis in all the divisions was caused by three pathogenic *Trypanosoma* spp. notably *T. congolense*, *T. brucei brucei* and *T. vivax*.
Ndoki et al., (1991)	Les glossines. In: Élevage et potentialités pastorales sahéliennes. Synthèses cartographiques: Nord-Cameroun = Livestock production and sahelian rangelands potential. Cartographic synthesis: North-Cameroon	To update on the eradication campaigns in the North region	The past eradication campaigns were successful, but re-invasion remained problematic.
Ngomtcho et al., (2017)	Molecular screening of tsetse flies and cattle reveal different Trypanosoma species including T. grayi and T. theileri in northern Cameroon	To study the occurrence of pathogenic trypanosomes in tsetse flies and cattle in tsetse fly-infested areas of Northern Cameroon	This study revealed active foci of trypanosomes in Dodeo and Gamba
Paguem et al., (2019)	Widespread co-endemicity of	To study the occurrence and	The abundance of pathogenic trypanosomes in tsetse infested areas is alarming and even more, the occurrence of *T. vivax*, *T.*

	Trypanosoma species infecting cattle in the Sudano Sahelian and Guinea Savannah zones of Cameroon	genetic diversity of trypanosomes in cattle from two agroecological zones (AEZ), focusing on areas with and without tsetse vectors	*brucei*, *T. congolense*, *T. theileri* and *T. grayi* in tsetse-free areas implies that tsetse control alone is not sufficient to control trypanosomosis in livestock.
Rageau and Adam, (1953)	Répartition des glossines au Cameroun français (1953)	To map tsetse flies distribution in French Cameroon	*G. tachinoides* and *G. morsitans submorsitans* were the only two species in the North region among the 12 species identified in French Cameroon.
Sevidzem et al., (2022a)	Spatial meta-analysis of the occurrence and distribution of tsetse-transmitted animal trypanosomiasis in Cameroon over the last 30 years	To map the occurrence and distribution of tsetse flies and animal trypanosomiasis in Cameroon	*G. tachinoides* and *G. morsitans submorsitans* were the only two species present in the North region.
Sevidzem et al., (2022b)	Tabanid-transmitted animal trypanosomiasis in Cameroon: evidence from a study in the tsetse free pastoral zone of Galim	The objectives of this study were: (i) To trap and determine the species richness and abundance of tabanids, (ii) To identify circulating trypansomes in cattle and tabanids in a tsetse free area and (iii) To map AAT and tabanids presence data	*Trypanosoma evansi* DNA was detected in tabanid samples from a tsetse free area for the first time.
Sevidzem et al., (2021).	A nationwide survey of the tabanid fauna of Cameroon	To provide current data on the species composition, abundance and distribution of tabanids in the five main agro-ecological zones (AEZs) of Cameroon.	The distribution maps of the newly identified tabanids differed between AEZs, with most tabanids collected from the Guinean savanna. The highest apparent density of tabanids was recorded in the Sudan Savanna region.

Sevidzem et al., (2016)	First Inventory of Non-biting and Biting Muscids of North Cameroon	To determine the relative abundance of biting and non-biting muscids in Mayo Rey	*G. morsitans submorsitans* and *G. tachinoides* and *Musca domestica* were identified and co-existed in the same biotope.

REFERENCES AND NOTES

1. Abah S. Tsetse control activities in Cameroon since November 2018. Annual report of the Special Mission for Tsetse Fly Eradication (MSEG) for 2020; 12.
2. Abro Z, Kassie M, Muriithi B, Okal M, Masiga D, Wanda G. The potential economic benefits of controlling trypanosomiasis using waterbuck repellent blend in sub-Saharan Africa. Plos One 2021; 16:e0254558. doi: 10.1371/journal.pone.0254558
3. Achiri FM. Le Rapport de la Division Tse-Tse Nord et L'Extreme Nord Premier Semestre 2018; 4.
4. Achiri FM. Annual report of Special Mission for Tsé tsé Eradication (MSEG) from 2014 to 2015; 5.
5. Achiri FM. Annual report of Special Mission for Tsé tsé Eradication (MSEG) from 2015 to 2016; 8.
6. Achukwi MD, Musongong GA. Trypanosomosis in the Doayo/Namchi (*Bos taurus*) and zebu white Fulani (*Bos indicus*) cattle in Faro division, North Cameroon. J App Biosc 2009; 15(1):807–14.
7. Awa DN, Ndamkou CN. Response of *T. vivax* and *T. congolense* in Zebu cattle in North Cameroon to prophylactic treatment with two formulations of Isometamidium. Prev Vet Med 2006; 76(1-2):90-96.
8. Bakary M. An account of the execution of the 5th Joint Campaign 1974/1975 against glossines at the border between Cameroon and Nigeria. Report of anti-glossine fight campaign of Benoue 1975; 7.
9. Bakary M. Joint campaign from 1975 to 1976 against glossines at the border between Cameroon and Nigeria. Report of anti-glossine fight campaign of Benoue 1976; 12.
10. Boulangé A, Lejon V, Berthier D. The COMBAT project: Controlling and progressively minimizing the burden of vector-borne animal trypanosomosis in Africa [version 2; peer review: 3 approved] Open Res Europe 2022; 2:67. doi: 10.1268 8/openreseurope.14759.2
11. Fauron A, Omarou F, Selby R, Holt H, Napier G, Guitian J. Baseline study for the integration of novel treatments, vaccines and diagnostics into Animal African Trypanosomosis control programmes: Cameroon Field Study Report. GALV med report 2014; 25.
12. Fernagut R. Execution of an experimental campaign against glossines in the Garoua Region. Report of the livestock section of North 1967; 19.
13. Gruvel J. Établissement de la division d'éradication des glossines de la Bénoué (Cameroun). Rapport technique : lutte contre les trypanosomoses – Rome, FAO 1979; 44.
14. Gruvel J, Fernagut R, Simeon M. Execution of a campaign against glossines in North Cameroon in the Mayo-Kebbi valley and Bénoué. Rev Elev Med Vet Pays trop 1970b; 23:93-99.
15. Gruvel J, Troncy P, Tibayrenc R. Contribution to the knowledge of the distribution of glossines in North-Cameroon. Rev Elev Med Vet Pays trop 1970a; 23:83-91.
16. Hamon J, Challier A, Mouchet J. Biology and control of tsetse flies. WHO inter-regional seminar on entomology methods in vector control 2021.
17. Lendzele SS, Abdoulmoumini M, Lydie AY. Spatial repartition of tabanids (Diptera: *Tabanidae*) in different ecological zones of North Cameroon. Biodiversity Int J 2017; 1 (2):64–68. doi: 10.15406/bij.2017.01.00010.
18. Mamoudou A, Ebene NJ, Fongho SP, Mfopit MY. Prevalence and impact of bovine trypanosomiasis in Mayo Rey division, a Soudano-Sahelian zone of Cameroon. J Parasitol Vector Biol 2015a; 7(5):80-88.
19. Mamoudou A, Fongho SP, Ebene NJ. Trypanosomes and helminths infections in Mayo Rey Division of Cameroon and impact of concurrent infections on cattle. J Vet Med Anim Hlth 2015b; 7(6):215-220.
20. Mamoudou A, Marceline M, Pierre F, Lendzele S, Oumarou F, Grabed R, Kingsley M, Mbunkah A. Tabanids (Diptera: *Tabanidae*) fauna composition in different sites and biotopes of Far-North, Cameroon. J Biol Nat 2016b; 6(3):146–154.
21. Mamoudou A, Njanloga A, Hayatou A, Suh PF, Achukwi MD. Animal trypanosomosis in clinically healthy cattle of North Cameroon: Epidemiological implications. Parasit Vectors 2016a; 9:206.
22. Mamoudou A, Sevidzem SL, Feussom JM, Mfewou A. Evaluation of efficacy of Deltamethrin 10%-impregnated screens in a tse tse endemic area in the Sudano-Sahelian region of Cameroon. Walailak J Sci Tech 2017; 14(11):893-909.
23. Mamoudou A, Sevidzem S. Bovine trypanosomiasis prevalence and its major vector density in the major cattle rearing regions of Cameroon (Extreme North, North,

Adamawa and North West): Past, Current and Future. In: Advances in Medicine and Biology Editor: Leon V Berhardt. Nova Science Publishers Inc 2017; 105:203.

24. Meyer A, Hannah RH, Oumarou F, Kalinga C, William G, Albane F, Chisoni M, Guitian J. Integrated cost-benefit analysis of tse tse control and herd productivity to inform control programs for animal African trypanosomiasis. Parasit Vectors 2018; 11:154 doi: 10.1186/s13071-018-2679-x
25. Meyer A, Holt HR, Selby R, Guitian J. Past and Ongoing Tsetse and Animal Trypanosomiasis Control Operations in Five African Countries: A Systematic Review. Plos Negl Trop Dis 2016; 10(12):e0005247. doi: 10.1371/journal.pntd.0005247
26. Mouchet J, Delas A, Yvore P. Experimental campaign against *G. tachinoides* West. In Logone Birni. Report of Technical Session 1961; 4.
27. Munn Z, Peters MDJ, Stern C, Tufanaru C, McArthur A, Aromataris E. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. BMC Med Res Methodol 2018; 18:143. doi: 1 0.1186/s12874-018-0611-x
28. Nchare A. Annual report of Special Mission for Tsé tsé Eradication (MSEG) from 1993 to 1994; 11.
29. Ndamkou CN, Nchare A. Bovine trypanosomiasis in North Province of Cameroon. Garoua, Cameroon: Laboratoire National Veterinaire de Bokle 1995; 30.
30. Ndoki N, Dubois PR, Le Grand G. Les glossines. In: Élevage et potentialités pastorales sahéliennes. Synthèses cartographiques: Nord-Cameroun = Livestock production and sahelian rangelands potential. Cartographic synthesis: North-Cameroon. Dongmo Jean-Louis, Tacher Georges. CIRAD-IEMVT – FRA. Wageningen: CTA-CIRAD-IEMVT 1991; 18-19.
31. Ngomtcho SCH, Weber J, Ngo Bum E, Terlumu GT, Kelm S, Achukwi MD. Molecular screening of tsetse flies and cattle reveal different *Trypanosoma* species including *T. grayi* and *T. theileri* in northern Cameroon. Parasit Vectors 2017; 10:631.
32. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD. The PRISMA 2020 statement. An updated guideline for reporting systematic reviews. Br Med J 2021; 372 :71.
33. Paguem A, Abanda B, Ndjonka D, Weber JS, Ngomtcho SCH, Manchang KT, Mamoudou A, Eisenbarth A, Renz A, Kelm S, Achukwi MD. Widespread co-endemicity of *Trypanosoma* species infecting cattle in the Sudano Sahelian and Guinea Savannah zones of Cameroon. BMC Vet Res 2019; 15:344.
34. Rageau J, Adam JP. Répartition des glossines au Cameroun français (1953). Revue Élev Méd Vét Pays trop 1953; 2:73-76.
35. Sevidzem SL, Abah Sl, Nguetoum C, Kong AB, Koumba AA, Mavoungou JF. Tabanid-transmitted animal trypanosomiasis in Cameroon: Evidence from a study in the tsetse free pastoral zone of Galim. Parasit Epidemiol Control 2022b; 18:e00253.
36. Sevidzem SL, Koumba AA, Mavoungou JF, Windsor PA. Spatial meta-analysis of the occurrence and distribution of tsetse-transmitted animal trypanosomiasis in Cameroon over the last 30 years. Epidemiol Infect 2022a; 150:e97, 1–13.
37. Sevidzem SL, Koumba AA, Yao-Acapovi GL, Mavoungou JF. A nationwide survey of the *tabanid* fauna of Cameroon. Parasit Vectors 2021; 14:392.
38. Sevidzem SL, Mamoudou A, Acapovi-Yao GL, Achiri M, Tchuinkam T, Zinga-Koumba CR, Mavoungou JF. First Inventory of Non-biting and Bitting Muscids of North Cameroon. Int Res J Biol Sci 2016; 5(10):12-20.
39. Simo G, Magang EMK, Mewamba EM, Farikou O, Kamga RMN, Tume C, Solano P, Ravel S. Molecular identification of diminazene aceturate resistant trypanosomes in tsetse flies from Yoko in the centre region of Cameroon and its epidemiological implications. Parasit Epidemiol Control 2020; 7:9. doi: 10.1016/j.parepi.2020.e00135