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Review

African animal trypanosomosis in cattle in Bénin: A review

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African animal trypanosomosis is a disease transmitted by tsetse flies and tabanid to domestic mammals which seriously affects their health status and considerably reduces their productivity. This study proposes to make a synthesis on the bovine trypanosomosis and the various works undertaken in Benin country from 1960 to 2018. After general information on bovine trypanosomosis, the various vectorial agents responsible for the disease are explained. The inventory of fixtures of the pathology since 1960 to 2018 followed by the measures and means of control will be detailed. Then, a point on the state of the trypanosome's chemotherapy -resistance facing circulating drug and of the approaches of solutions and the convincing alternatives will be developed. Finally, a study of the impact of transhumance transmission in the maintenance of bovine trypanosomosis supported by the management of conflicts is exposed. The chemotherapy-resistance of the trypanosomes being a true problem affecting the control of the disease, then it is urgent to find endogenous solutions that are reliable through the valorization of medicinal herbs for an effective control of bovine trypanosomosis in Benin. The present work opens a perspective on the definition of innovative alternatives to fight against the bovine trypanosomosis as well as tackle the chemotherapy-resistance against circulating *Trypanosoma* spp.

Key words: Alternatives, chemotherapy, drug, resistance, *Trypanosoma* spp, Bénin.

INTRODUCTION

Animal trypanosomoses are a major constraint to the development of cattle livestock and other ruminants in more than 37 countries in sub-Saharan Africa. Considering itself a true scourge in central and western

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Africa, African animal trypanosomosis persistence is a major animal health problem with consequences for high morbidity and mortality (Hursey and Slingenbergh, 1995; Lekeux, 2006; Odeniran et al., 2018). It is a cyclic disease transmitted mainly by tsetse flies and other blood-feeding insects of Tabanidae may transmit the trypanosomosis mechnically (Troncy et al., 1981; Itard, 1986; Kumar et al., 2012; Sharma et al., 2012; Singla et al., 2013; Sumbria et al., 2015; Bassi et al., 2018), which seriously affects livestock development. Sometimes called "Nagana", it is a serious parasitosis caused by unicellular parasites: *Trypanosoma vivax, T. congolense, Trypanosoma brucei, Trypanosoma simiae,* and *Trypanosoma suis* (Desquesnes et al., 2009; Ahmed et al., 2016). Disease affects ruminants, pigs, horses and carnivores, but has a serious effect on livestock production and lowers the economic power of cattle producers (Shaw et al., 2014). Trypanosomosis causes a lot of economic losses in livestock production (Hurtado et al., 2016). In 2002, Beninese cattle herd was estimated at 1,300,000 of which 10.50 to 45.00% of each herd may have been infected with trypanosomosis (Codjia, 1989).

Trypanocidal drugs rank first among veterinary pharmaceutical inputs (Vaccines, Anthelmintics, Antibiotics and others) sold by PHARNAVET (Assogba, 2001). Chemotherapy and chemoprevention remain the only means of combating African animal trypanosomosis (Giordani et al., 2016), but several poor or counterfeit products are placed on the market (Sutcliffe et al., 2014; Tchamdja et al., 2016), which promotes the resistance of trypanosome species to circulating trypanocides (Van den Bossche and Delespaux, 2011); which makes it difficult to control the disease.

Beninese government has set up several Livestock Development Programs, the most recent being the Milk and Meat Sector Support Program (PAFILAV). This program aims to control various animal pathologies, including African animal trypanosomosis, which is a real constraint to the development of cattle breeding in Benin. The present work allows us to take stock of all the activities carried out on African animal trypanosomosis in Benin and to propose alternatives in face of the alarming drug resistance that nowadays infringes the cattle development in Benin.

Overview on African animal trypanosomosis

Definition

Animal trypanosomoses is a vector-borne haemoparasitic disease (Juyal et al., 2005; Franco et al., 2017; WHO, 2018). It is the most important and seasonal diseases affecting livestock caused by *Trypanosoma* spp*.* (Diallo et al., 2018; Jaimes-Dueñez et al., 2018). In Africa, this infection is caused by several species of trypanosomes including *Trypanosoma congolense, T. vivax, T. simiae, T. evansi* and *T. brucei*, which are transmitted cyclically by tsetse flies of the genus *Glossina* (CFSPH, 2009; Enyaru et al., 2010) and also mechanically by several biting insects (Tabnids, stomoxes, etc.) (Salih et al., 2015). It is a chronic disease of cattle and some mammals that that cause significant anemia as main symptom (Brown, 2008). The disease decreases the haematological indices for infected animals by making low the Packed Cell Volume (PCV) value (Ganyo et al., 2018). Animals infected can produces clinical signs of infection, and occasionally death in half of untreated animals (Osório et al., 2008; Desquesnes et al., 2013).

Synonyms

Trypanosomosis or typanosomiasis is the name of several diseases notify among vertebrates caused by haemo-protozoan flagellates (trypanosomes) of the genus *Trypanosoma*. Referring to animals, it is also call Nagana, Tsetse disease, Tsetse fly disease, trypanosomosis (Spickler, 2018). In humans this includes African trypanosomiasis and Chagas disease. Some other words can also refer to the disease. Among these words we can include: sleeping sickness; African sleeping sickness; catalepsy; encephalitis; encephalitis lethargica; narcolepsy and sleepy distemper.

Etiology and epidemiology

Etiology

Animal trypanosomosis is an important disease due to trypanosome that causes anemia, loss of condition, and emaciation in livestock (Spickler, 2018; Jaimes-Dueñez et al., 2018). Trypanosomes are protozoan parasites in the family *Trypanosomatidae*. African animal trypanosomosis is caused by those organisms that are transmitted by Tsetse flies (Spickler, 2018). The three most important species are *T. congolense* (subgenus *Nannomonas*), *T. vivax* (subgenus *Duttonella)* and *T. brucei* subsp. *brucei* (subgenus *Trypanozoon*)*.* There are three variants of *T. congolense*, called the savannah, forest and kilifi (or Kenya Coast) types. African animal trypanosomiasis can also be caused by *T. (Nannomonas) simiae*, *T. (Pycnomonas) suis*, *T. (Nannomonas) godfreyi* and *T. (Duttonella) uniforme,* and possibly by additional unnamed trypanosomes (Acha and Szyfres, 2003; Leukeux, 2006; Spickler, 2018). All trypanosome parasites are extracellular and flagellated (Leukeux, 2006; Brown, 2008).

Two related parasites, *T. brucei* subsp. *gambiense* and *T. brucei* subsp. *rhodesiense,* are transmitted by the bite of Tsetse flies (genus *Glossina*) cause human African trypanosomiasis, which is also known as sleeping sickness (Camara et al., 2005; Chimelli and Scaravilli, 1997; Spickler, 2018). The primary distinction between this disease and African animal trypanosomosis is that these two organisms can evade the innate resistance

humans possess against other tsetse-transmitted African trypanosomes (Spickler, 2018).Livestock can harbor pathogenic parasites for humans in particular *T. rhodesiense* and *T. gambiense* and act as a reservoir (WHO, 2019).

Epidemiology

Epidemiology of trypanosomosis aims to understand a modal of transmission, the incubation period of the disease, the morbidity and the mortality. The disease is transmitted from animal to animal thought the bite of an infected tabanids and tsetse flies such as *Glossina morsitans*, *G. palpalis* and *G. fusca.* The clinical sign of the disease is quite variable from 4 days up to 5 weeks (Brown, 2008). Morbidity can be expected to be very high when the tsetse challenge is also high. Therefore, sick animals or animals infected with any one of the three species of trypanosome and unless treated will probably die of the disease (Brown, 2008).

Diagnosis

The incubation periods start from 4 days to approximately 6 weeks in ruminants. More virulent isolates seem to have a shorter incubation period, often 2 weeks or less (Spickler, 2018). Diagnosis of animal trypanosomosis is based on two types of procedures. It is essentially about a field diagnosis and laboratory diagnosis (Brown, 2008).

Field diagnosis: based on the observation of pathognomonic signs of bovine trypanosomosis. It characterized by sickness, severe anemia in an endemic area, emaciation, watering. The next is the prompt collection of sample for laboratory diagnosis.

Laboratory diagnosis

This part is realized in two steps, the collection of the samples and the technical procedures:

Samples:

The sample can be the serum, blood, thick and thin blood smears, lymph or buffy coat (OIE, 1992; Brown, 2008).

Laboratory procedures:

Trypanosomosis may be diagnosed by microscopic examination of wet and stained thick or thin blood films, impression smears from lymph node aspirates, Polymerase chain reaction (PCR), Enzyme-linked immuno sorbent assay (ELISA) or indirect fluorescent antibody (IFA) (OIE, 1992; Brown, 2008).

Multiple vectors of African Animal Trypanosomosis (AAT) in Benin

Seven species of tsetse flies have been recorded in Benin (Table 1). They belong to the subgenus *Austenina* (*fusca* group), *Glossina* (*morsitans* group) and *Nemorhina* (*palpalis* group) (Table 1). Three tsetse species predominate in northeastern Benin; they are *Glossina tachinoides*, *G. palpalis gambiensis* and *G. morsitans submorsitans* (Dehoux, 1993). *Tabanus biguttatus* is one of the most abundant Tabanid kinds in Benin (Vala and LeClercq, 1993). D'Amico et al., (1996); Desquesnes and Dia (2004) reported in Central Africa and Burkina-Faso that flies, Stomoxys and Tabanids are responsible for the mechanical transmission of *T. vivax* and *T. congolense*. Several other hematophagous flies are also involved in the transmission of *T. vivax* to Nigeria. Several other hematophagous flies species of *Tabanidae* (*T. taeniola*, *T. biguttatus*, *T. pluto*, *T. latipes, T. fasciatus, T. subangustus, T. gratus, T. fuscipes*, *T. par, T. pertinens, T. secedens, T. albipalpus, T. neocopinus* and *T. thoracinus*) are also involved in the transmission of trypanosomosis to Nigeria (Dipeolu, 1977; Ahmed et al., 2005).

Prevalence of African Animal Trypanosomosis in Bénin from 1960 to 2018

Several studies have been conducted to evaluate the prevalence of African bovine trypanosomosis in Benin using microscopy, serological tests and molecular techniques in tsetse flies and animals. Several reports have been based on the assessment of animal overweight, low hematocrit that may be a consequence of trypanosomosis and microscopy (OIE, 2013). For several studies, the buffy coat technique, smears and thick drops observed using microscopy are used. According to Picozzi et al. (2002) and Uilenberg (2011), 75% of cases of trypanosomosis diagnosis are based on microscopy and serological techniques do not allow diagnose of mixed infections, previous ones and new infections. Epidemiological surveillance techniques by molecular characterization provide more details on the infection status of cattle (Picozzi et al., 2002). A summary of studies examining African animal trypanosomosis in Benin from 1960 to 2017 is presented in Table 2 with a wide range of prevalence (5.00 to 89.80%).

National control campaigns in Bénin

Before independence, zootechnical studies and animal disease control were undertaken on two farms in the State of Benin. The first one is Okpara created in 1952 in the department of Borgou and the second Kpinnou

Table 1. Species of tsetse flies present in Benin.

Group *Morsitans* (Subgroup *Glossina*) [Savannah]	Group *Palpalis* (Subgroup *Nemorhina*) [Riverine]	Group *Fusca* (Subgroup *Austenina*) [Forest]
Glossina longipalpalis	*Glossina palpalis palpalis*	*Glossina fusca congolensis*
Glossina morsitans submorsitans	*Glossina palpalis gambiensis*	*Glossina medicorum*
-	*Glossina tachinoides*	-

Source: Pollock (1982); Itard (1986).

Table 2. Summary of research on trypanosomosis in Benin.

Author and year	Animal species	Tests	Prevalence (%)	Localities
Codjia (1989)_	Cattle	Blood smears	22.5	Borgou, Bénin
Doko et al. (1991)	Cattle	Blood smears	19.3	Abomey-Calavi, Bénin
		IFAT	89.8	
		CATT	50.6	
		Trypanolytic test	3.4	
Lekeux (2006)	Cattle	Blood smears	5 - 63	Bénin, 1991-2004
Farougou et al. (2012)	Cattle	Woo method	6.7	Ouaké, Bénin
	Sheep		3.8	
Hestin (2012)	Cattle	Blood smears	13.14	Departement of Zou, Mono, Borgou, Ouémé

created in 1958 in the department of Mono. This led to the creation of the first National Directorate of Livestock and Animal Industries in 1959 on the eve of independence. Due to political unrest in the country until 1972, no effective restructuring of the livestock service was obtained and this contributed to the persistence of major epizootics including bovine trypanosomosis in livestock in Benin. It took the creation of the Public Society for the Development of Animal Resources (SODERA) in 1972 to put in place effective health control policies against diseases with a strong economic impact, including trypanosomosis. In 1993, the Agricultural Services Restructuring Project (PRSA) was set up, led to the creation of the Ministry of Agriculture, Livestock and Fisheries (MAEP), and contributed to the development of animal production. As a result, two projects to improve cattle breeding and control of bovine trypanosomosis were set up. This is the Livestock Development Project (LDP) and the Milk and Meat Sector Support Project (PAFILAV). The Livestock Development Project (LDP) developed in 1997 was launched in the year 2000 and aimed at strengthening food security, improving the general standard of living of pastoralists and agro-pastoralists, and reducing poverty through the development of sustainable livestock farming based on better exploitation of resources and progressive integration of livestock and agriculture. To achieve its objectives, the project has built on the achievements of the second phase of the Animal Production Development Project (APDP). This Project also had a third phase that ensured the continuity of the measures that ended on June 30, 2006.

The Milk and Meat Sector Support Project was identified in June 2007 by a mission of the African Bank of Development following the request of the Government of Benin in 2005. The project is part of the OSD 2006 to 2011 and the growth strategy for poverty reduction (SCRP, 2007; 2008; 2009), including the SCRP Priority Actions Program which includes improving agricultural productivity and production. The project will thus contribute to the achievement of the specific objectives assigned to these sectors, included in the Strategic Plan for the Revival of the Agricultural Sector (PSRSA) and aimed at improving the breeding of livestock and control of diseases such as trypanosomosis, other parasitic, viral and bacterial diseases.

The implementation of numerous breeding projects, Pan African Program for the Control of Epizootics (PACE), Livestock Development Project, stage III (LDP III), Livestock Development Project in East Borgou (PDEBE), and Livestock Development Support Project in Borgou (PADEB) over the last ten years has reached cattle and small ruminants. The main activities focused on animal health, zootechnics and research and development (PDE, 2007).

Trypanocidal drug resistance and sub-standard drugs

For several decades, the control of African animal

trypanosomosis has been mainly based on the use of trypanocides for prevention and treatment (Murray et al., 1998; Giordani et al., 2016; Dagnachew et al., 2017). Animal disease control measures through chemotherapy better protect animals than any other methods (Budd, 1999). The increase in trypano-resistance that promotes the resistance of trypanosome species to circulating trypanocidal drugs (Van den Bossche and Delespaux, 2011) is due to the negligence of some unscrupulous trypanocidal drug deliverers, the continued and abusive use of trypanocidal drugs by breeders or unqualified people, under-dosing, finally a limited number of circulating trypanocidal molecules (Assogba, 2001; Dagnachew et al., 2017) as well as the circulation of trypanocidal products of poor quality or counterfeit on the market (Vitouley et al., 2012; Sutcliffe et al., 2014; Tchamdja et al., 2016).

Some studies have also shown the misuse of veterinary drugs as the major cause of drug resistance in Africa (Teko-Agbo, 2008; Gberindyer et al., 2014). These states of affairs make it difficult to control the disease. According to Mainguet (2000), the resistance of a trypanosome species is conserved during the life cycle of the tsetse fly. This period varies from one species to another, 16 months for *T. vivax* and 12 months for *T. congolense*. Trypanocidal drug resistance is a critical issue that needs to be constantly addressed. Resistance to the trypanocidal drugs used is a major problem in livestock farming in Africa (Delespaux et al., 2008) but the breeders do not have a good knowledge on the concept of drug resistance (Sinyangwe et al., 2004).

Cases of resistance of trypanosomes to isometamidiun are reported (Delespaux et al., 2008) throughout Africa and more precisely in Ethiopia and Burkina Faso (Clausen, 2005), Mozambique (Jamal et al., 2005), Nigeria (IIemobade, 1979) and Bénin (Vitouley, 2014). To reduce the risk of developing drug resistance, the frequency of trypanocidal use must be kept to a minimum (Geerts and Holmes, 1998).

Impact of transhumance in the maintenance of bovine trypanosomosis and management of conflicts in Bénin

In Bénin, Fulani people migrate to southern areas in search of fodder and water due to drought (Agossou et al., 1998). Livestock management is characterized by migratory movements. These displacements sometimes create conflicts between breeders and crop farmers and favor the maintenance of vector-borne diseases such as bovine trypanosomosis (Agossou et al., 1998). Conflicts occur mainly at the beginning of the rainy season when pastoralists prefer new fallow regrowth for the grazing of their animals. This poses a problem of poor occupation of spaces because of the planting of crops (De Haan, 1997). To solve this problem, the Beninese State has made a lot of effort and has taken steps for setting up transhumance committees at local, national and regional levels. Few improvements have been achieved. With the option of decentralization of the Beninese State and transfer of competence to peasant organizations that emanate from the historic decisions of the National Conference from 19 to 28 February 1990, research and development has been developing since 1996 in the north (Agossou et al., 2003) and Benin Center (Agossou et al., 2003; Maliki et al., 2001), a participatory approach to assist some rural communities in the learning and conflict management experience. Transhumance is regulated by laws, decrees, decisions and regulations made at municipal and national level (Djohy, 2010). The laws that regulate transhumance are: Law No. 87-013 of 21 September 1987 regulating pasturage, keeping of domestic animals and transhumance; Interministerial Order 1992-No. 010/MISAT/MDR/D-CAB of 20 January 1992, establishing, organization, functions and operation of transhumance committees in the Republic of Benin; Law No.93-009 of July 2, 1993 bearing forest regime in the Republic of Benin and Decree No.96-271 of July 2, 1996 bearing the terms of application of law No. 93-009 of July 2, 1993; the 1994 decree No.0039 /MISAT/MDR/DGAR concerning the organization of transhumance 1993-1994; Law No. 2002-016 of October 18, 2004, on the fauna regime in the Republic of Benin (Without implementing decree); Interministerial Order 2006-N° 2176/APRM/MSPCL/DCAB/SGM/ DRH/DE/SA of July 7, 2006 mandatory and synchronous rendering the vaccination of the animals against the septicemia, hemorrhagic and the Contagious Peri-pneumonia in the bovine species, throughout the national territory and decree No. 2009-241 of June 9, 2009 establishing the committee responsible for resolving recurrent transhumance problems between Fulani pastoralists and farmers in the national territory.

In all the communes concerned by transhumance, the town halls of the latter take orders to regulate transhumance in their territories. We can quote: decree No. 54/024/MKDI/SG/SGA/ SA of July 27, 2006, on creation, composition and functioning of communal committee of transhumance of the municipality of Kandi; Decree No. 014/M-CKM/SG/BAGD of 1 October 2004 regulating grazing, keeping of domestic animals and transhumance in the commune of Karimama; Decree No. 16/MCKM/SG/BAGD of October 20, 2004, establishing, assigning and functioning of communal, district and village committees, prevention and management of livestock-farmer conflicts in the municipality of Karimama and the decree No. 54/024/MOI/SG/SGA/SA of September 16, 2009, concerning creation, composition and functioning of communal committee of transhumance of the commune of Ouinhi.

CONCLUSION

Benin is a country with a high agropastoral activity, but

breeding is slow to take off because of sanitary constraints. African animal trypanosomosis is one of the major constraints affecting the economy and productivity of livestock. Despite the control measures implemented for several years through to livestock development projects, bovine trypanosomosis persists and continues to be a major obstacle to improving livestock productivity in Benin. In order to control the disease and ensure good livestock performance, effective control measures against tsetse vectors and extension of control policy to all endemic areas will be required. It is also clear that the government and authorities in charge of livestock development are making better arrangements for the operationalization of the control and eradication of African animal trypanosomosis.

ETHICAL STATEMENT

The present work was conducted under the permission of the University of Abomey-Calavi through the Project FNRSIT-FC 2015.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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