# **Trypanosomosis in Goats**

# **Current Status**

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ABSTRACT: Trypanosomosis is a major constraint on ruminant livestock production in Africa, Asia, and South America. The principal host species affected varies geographically, but buffalo, cattle, camels, and horses are particularly sensitive. Natural infections with Trypanosoma congolense, T. vivax, T. brucei, and T. evansi have been described in goats. Trypanosomosis in goats produces acute, subacute, chronic, or subclinical forms, being T. vivax, T. congolense, and T. evansi, the most invasive trypanosomes for goats. However, the role of goats in the epidemiology of trypanosomosis is largely discussed and not well understood. Thus, it has commonly been assumed that trypanosomosis presents a subclinical course and that goats do not play an important role in the epidemiology of the disease. This can partially be due to parasitemia caused by trypanosomes which has been considered low in goats. However, this assumption is currently undergoing a critical reappraisal because of goats may also serve as a reservoir of trypanosome infection for other species, including the human beings in the case of T. brucei rhodesiense. The present article describes the current status of trypanosomosis in goats in Africa. Asia. and South America. Pathogenesis. clinical features. diagnosis, and treatment of the different trypanosomes are also described. The possible role in the epidemiology of the disease in the different areas is also discussed.

KEYWORDS: Trypanosoma spp.; trypanosomosis; goats; current status

# INTRODUCTION

Trypanosomosis is a major constraint on ruminant livestock production in many areas of Africa, Asia, and South America. Many animal species can be

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affected by the different trypanosomes, thus severely impairing the economic efficiency in endemic areas.

*Trypanosoma* are classically divided into Stercoraria and Salivaria sections, according to their life cycle in the insect vector. Within the Salivaria section, some species (e.g., *T. congolense* and *T. brucei*) are transmitted only by tsetse flies (*Glossina* spp.) and are called the tsetse-transmitted trypanosomes. Others may be either cyclically transmitted by tsetse flies, or mechanically transmitted by other hematophagous insects (e.g., *T. vivax*). Still others are only mechanically (*T. evansi*) or sexually (*T. equiperdum*) transmitted (TABLE 1).

Tsetse-transmitted trypanosomosis is a disease complex caused by several species of *Trypanosoma*. The many species of tsetse infest 10 million square kilometers and affect 37 countries in Africa. The disease affects both humans and livestock. It is currently estimated that about 50 million people<sup>1</sup> and 48 million cattle<sup>2</sup> are at risk of contracting trypanosomosis. From an economic point of view, the disease is particularly important in cattle, although other mammals can also be affected. The livestock-carrying capacity of such areas in West and Central Africa could be increased five- to sevenfold by eliminating or controlling animal trypanosomosis.<sup>3</sup>

Trypanosomosis caused by *T. evansi* (surra) is the most widely distributed of the pathogenic animal trypanosomes affecting livestock in South America, Africa, and Asia. The most affected animal species are buffalo, horses, camels, and cattle, although geographical differences are observed. Other hosts, including small ruminants, can be affected.

There are approximately 228 million goats in Africa<sup>4</sup> (data on Somalia are not available) with as many as 173 million in the tsetse-infested regions of the continent.

It is commonly believed that goats are highly resistant to infection, that caprine trypanosomosis is only sporadic, and that the disease in goats is of little economic consequence.<sup>3</sup> However, current epidemiological information indicates that goats can play an important role in the dissemination of the disease. Thus, goats naturally infected with *T. congolense*, *T. vivax*, or *T. brucei* and presenting clinical disease are regularly observed in Africa. Regional differences in the prevalence of caprine trypanosomosis exist, but can be high in some areas.<sup>5,6</sup> In general, caprine trypanosomosis is more common in East than in West Africa. This has been attributed to differences in feeding preferences between riverine and savannah species of *Glossina*; the latter being more inclined to feed on goats.<sup>7</sup>

Trypanotolerance has clearly been established in cattle, particularly in the breeds N'dama of West Africa and West African Shorthorn. The existence of trypanotolerance in certain goat and sheep breeds is under study. Dwarf goats are known to be more resistant to trypanosomosis than exotic breeds or breeds living in tsetse-free areas.<sup>5,8</sup> Studies carried out by Goossens *et al.*<sup>9</sup> seem to demonstrate that African Dwarf goats are less trypanotolerant than Djallonke

TABLE 1. Trypai	nosomosis in goats Maior species		Vectors	Natural	Experimental	
Species	affected	Geographic distribution	involved	infection in goats	infection in goats	Clinical manifestation
T. vivax	Domestic ruminants, camels, horses, antelope	Widespread in tropical Africa and South America	Glossina spp., various biting flies	Common	Readily	Acute and chronic forms, mild to fatal
T. uniforme	Domestic ruminants, antelope	Zaire, Uganda	Glossina spp.	Yes	Not reported	Nonpathogenic or subclinical infection
T. congolense	All domestic animals, wild game	Widespread in tropical Africa	Glossina spp.	Common	Yes	Acute, subacute, and chronic forms, mild to fatal outcome
T. simiae	Domestic pigs, camels, wild warthogs	Widespread in tropical Africa	Glossina spp. and Stomoxys, Tabanus filies	Uncommon	Not reported	Mainly subclinical or mild clinical disease
T. brucei	Domestic ruminants, horses, dogs and cats	Widespread in tropical Africa	Glossina spp.	Common but with strain variation	Yes, with strain variation	Noninfective to fatal outcomes
T. b. gambiense (West African sleeping sickness	Humans	Tropical West and Central Africa	<i>Glossina</i> spp. and various biting flies	Uncommon	Yes	Noninfective or a chronic form leading to death or spontaneous recovery
T. b. rhodesiense (East African sleeping sickness)	Humans	East and Southern Africa	Glossina spp.	Uncommon	Yes	Experimental infections subacute and fatal
T. evansi	Camels, equines, dogs, water buffaloes	India, Far East, Near East, Philippines, North Africa, Central and South America	Various biting flies	Yes	Yes	Subclinical, moderate or acute disease.
T. equiperdum	Horses	Northern and South Africa, Central and South America, Mexico, Middle East, Italy, former USSR	Venereal reported	Not reported	Not reported	Not reported
<i>T. cruzi</i> (Chagas disease)	Humans	South and Central America, sporadic in USA	Reduviid blood-sucking bugs	Yes	Yes	Not reported
SOURCE: Adapted f	rom Reference 7.					

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sheep. The trypanotolerance in cattle has been defined as their ability to control parasitemia and anemia.<sup>10</sup> However, small ruminant are less able to control parasitemia and drop in packed cell volume (PCV) following trypanosome infection.<sup>11</sup> On the other hand, Murray *et al.*<sup>12</sup> described that *Glossina* flies may select other livestock over goats when mixed animal populations are present, which can contribute to survival in tsetse areas. The studies carried out in goats seem to be insufficient to understand the true mechanism of trypanotolerance in this species.

Regarding treatment, drug resistance has become a significant problem because no new drugs have been marketed for quite some time. In general, curative doses used in cattle are also appropriate for goats and sheep.<sup>13</sup> Diminazene aceturate is given intramuscularly as a 7% water solution at a dose of 3.5 mg/kg; quinapyramine dimethyl sulfate given intramuscularly as a 10% water solution at a dose of 10.0 mg/kg. Both are considered as very effective. Relapse of infection has been reported in goats treated with diminazene aceturate, presumably because of re-emergence of trypanosomes from the central nervous system where they were inaccessible to the drug during earlier treatment.<sup>8</sup>

Homidium chloride or homidium bromide are given in a 2% water solution at a dose of 1.0 mg/kg intramuscularly, both are effective against *T. vivax* and *T. congolense*. Isometamidium chloride is also effective against the trypanosomes in the blood when given at a dose of 0.25-0.75 mg/kg intramuscularly as a 1% or 2% water solution. This drug was shown to produce signs of shock or death in goats if given intravenously at doses greater than or equal to 0.5 mg/kg.<sup>14</sup> Goats experimentally infected with *T. evansi* were cured after a single inoculation of 0.3 mg/kg of an arsenal compound (Cymelarsan<sup>®</sup>; Merial, Lyon, France).<sup>15</sup>

In many areas in the world, goats are reared near or in contact to highly susceptible species (particularly cattle, dromedaries, and horses). However, their role as possible reservoirs and carriers of the trypanosomes is largely discussed. In this article, we expose the current knowledge of trypanosomosis in goats.

#### T. EVANSI

*T. evansi* is the causative agent of surra, a disease of camel and horses that produces important economic losses in endemic areas (FIGS. 1–3). The disease has been described in small ruminants causing subclinical infection,<sup>16–18</sup> moderate infection,<sup>19</sup> and severe infection.<sup>19,20</sup> Ngeranwa *et al.*<sup>19</sup> described erratic parasitemia, weight loss, and significant drop in PCV in an experimental inoculation using a *T. evansi* strain isolated in Kenya and inoculating small East African bucks. Natural infection has been described in goats by serology<sup>21,22</sup> in a survey carried out in Sudan. However, goats kept in contact with parasitemic camels and horses were found aparasitemic in Jordan.<sup>23</sup> To



**FIGURE 1.** Tropical area in Africa (tsetse area) as well as countries where *T. evansi* has been reported.

isolate *T. evansi* from affected goats is very difficult due to low parasitemia. Ngeranwa *et al.*<sup>19</sup> observed a predominant presence of *T. evansi* in extravascular locations (synovial, peritoneal and cerebrospinal fluids, and lymph nodes). *T. evansi* can pass to blood from these extravascular locations in febrile or advances stages in goats. Common parasitological detection tests for *Trypanosoma* spp. employed in other animal species are also valid for goats, including the mini anion exchange centrifugation technique.<sup>24</sup>

The small size of the caprine erythrocytes (3.2  $\mu$ m; for comparison: 6.5  $\mu$ m for camels, 5.5  $\mu$ m for horses, and 5.8  $\mu$ m for cattle) must be taken into consideration for obtain a valid PCV (Woo technique<sup>25</sup>). A mean cell hemoglobin concentration (MCHC) around 30–36% is considered a proper centrifugation for normal goat blood.<sup>26</sup>

Indirect methods seem to be more appropriate to detect *T. evansi* infections in goats. An enzyme-linked immunosorbent assay (ELISA) for the detection of *T. evansi* in goat sera using a monoclonal antibody has been reported.<sup>27</sup> Indirect immunofluorescence (IFI) has also been used to detect *T. evansi* antibodies in goats.<sup>28</sup> A direct card agglutination test (CATT/*T. evansi*) and an indirect latex agglutination test (LATEX/*T. evansi*) have been shown adequate to detect *T. evansi* antibodies in goat sera.<sup>29</sup>



**FIGURE 2.** Presence of *T. evansi* and *T. vivax* in South America based on Dávila and Silva.<sup>41</sup>

# T. CONGOLENSE

*T. congolense* is the most common trypanosome of goats in Africa. Goats can also act as a reservoir of *T. congolense* for other species. In the Sudan, goats infected with *T. congolense* developed a chronic form of disease from which many spontaneously recovered. When the organism was passaged from goats into calves, however, acute fatal bovine trypanosomosis occurred.<sup>18</sup>

The trypanotolerance to *T. congolense* of West African Dwarf goats is similar to its F1 crosses with the Sahelian breed (trypanosusceptible).<sup>30</sup> Similar results have also been reported by Dhollander *et al.*<sup>31</sup> studying West African Dwarf goats and its F1 crosses with Saanen goats (trypanosusceptible). The African



FIGURE 3. Asia. Countries in which T. evansi has been described.

gray duiker (*Sylvicapra grimmia*) is also considered as trypanotolerant, even much more than sheep and goats.<sup>32</sup>

*T. congolense* produces immunosuppressive effects in West African Dwarf goats infected simultaneously with *Haemonchus contortus*.<sup>30</sup> Experimental *T. congolense* infection in the same breed affected reproductive performance with abortions, premature births, and perinatal losses. Transplacental transmission of the parasite or lesions in placenta could not be demonstrated.<sup>33</sup> In another experimental inoculation of *T. congolense* in goats, Witola and Lovelace<sup>34</sup> indicated that erythrophagocytosis by mononuclear cells is a mechanism of anemia pathogenesis.

From the diagnosis point of view, detection of *T. congolense* DNA by polymerase chain reaction (PCR) using GOL as primer set was 100% concordant with buffy coat examination.<sup>22</sup> Also, an indirect ELISA to detect *T. congolense* antibodies in goats has been described by Lejon *et al.*<sup>35</sup>

#### T. BRUCEI

Natural infection of goats with *T. brucei* is sporadically reported. A survey carried out in Gambia showed that *T. brucei* was present in West African Dwarf goats but only in a few cases.<sup>36</sup> From the experimental viewpoint,

*T. brucei* infection has been reproduced in Nigerian West African Dwarf goats using a local virulent strain.<sup>37</sup> In an immunity study, infection of goats with *T. brucei* resulted in depressed responses to mitogen stimulation of lymphocyte transformation.<sup>38</sup>

Goats and other domestic animals are relatively resistant to *T. brucei gambiense*, which is the cause of West African human sleeping sickness; however, goats have been suggested as reservoir host of the parasite.<sup>39</sup> When infection does occur, the clinical course is chronic. *T. brucei rhodesiense* is an uncommon cause of caprine disease.<sup>7</sup> Goats also have been implicated as a reservoir of *T. brucei rhodesiense*, transmissible to man.<sup>40</sup>

## T. VIVAX

*T. vivax* is the second most common trypanosome of goats in Africa. *T. vivax* can be transmitted to domestic livestock by tsetse flies (*Glossina* spp., cyclical transmission) as well as directly (mechanical transmission) by other bloodsucking insects thus allowing *T. vivax* to extend its distribution beyond tropical Africa. *T. vivax* was introduced in South America in 1830 by a shipment of zebu cattle from Senegal.<sup>41</sup> Today, goats are recognized as reservoir host for *T. vivax* in many countries in South America.<sup>42</sup>

*T. vivax* produces immunosuppression, which has also been demonstrated in goats.<sup>43</sup> Thrombocytopenia, microthrombus formation and hemorrhage suggestive of disseminated intravascular coagulation (DIC) have been observed in goats infected with *T. vivax*.<sup>44,45</sup>

# T. CRUZI

Natural infection of *T. cruzi* in goats has been detected by Herrera *et al.*<sup>46</sup> using indirect fluorescent antibody test. Clinical manifestation of the disease has not been reported. Kids experimentally infected with *T. cruzi* showed no clinical signs of disease and carried the infection for 38 days.<sup>47</sup> Regarding the epidemiology of the disease in a Brazilian endemic area of Chagas' disease, Herrera *et al.*<sup>46</sup> described that goats did not play an apparent role.

### **OTHER TRYPANOSOMES**

Goats are susceptible to *T. uniforme*, in Uganda and Zaire, but only mild infections occur. *T. simiae*, a trypanosome of swine and camels is transmissible to goats by either *Glossina* spp. or by biting flies but causes mostly mild or subclinical disease.<sup>7</sup>

A nonpathogenic trypanosome, *T. theodori*, was found incidentally in goats in Israel.<sup>7</sup> It is transmitted by a hippoboscid fly, *Lipoptena caprina*. This

organism is morphologically similar to the common, nonpathogenic sheep trypanosome, *T. melophagium*.

In conclusion, goats are highly susceptible to pathogenic trypanosomes, although the disease follows commonly a subclinical course. Parasitemia is usually low but persistent, and therefore, goats can be considered as an important reservoir for the majority of trypanosomes of other animals and humans. In those areas of the world where the presence of goats is important (in desert or semi-desert zones), caprine trypanosomosis should be taken into consideration in all programs to control the disease.

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