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Camel Trypanosomiasis and Its Current Status in Ethiopia: A Systematic Review

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Abstract
Camel is comparatively less susceptible to many of the devastating diseases that affect other livestock species, such as rinderpest, contagious pleuropneumonia and foot and mouth disease but yet they are affected by many other diseases. The most important disease of camel is trypanosomiasis, vector born protozoal disease caused by Trypanosoma evansi parasite whith wide distribution throughout tropical and subtropical regions of the world.the aim of this manuscript is to review on available articles on camel trypanosomiasis focusing on current status of it in Ethiopia. Camel trypanosomiasis causes progressive anaemia, depression, dullness, loss of condition and often rapid death. Serology is a preferable diagnostic technique while suramin, diminazene aceturate, melarsomine and quinapyramine are drugs of choice for treatment. But due to drug resistance of the agent control of vectors transmitting the parasite is more important. Preveously, trypanosomiasis caused T.evansi were only a disesse of animals but its reported that frist case of T.evansi is confirmed in human. Furthermore, T.evansi type B that so far only isolated from camel in Kenya is recently confirmed in Ethiopia. Beside, causing great economic losses T.evansi is recently emerging as zoonotic disease and unexpected new strains are being isolated from previosly free areas. Therefore, routine epidemiological and biochemical studies should be performed to design and implement appropriate intervention measures.
Keywords: Camel trypanosomiasis, Trypanosoma evansi, Surra, Camel

Introduction

Livestock contribute 40 % of the global value of agricultural output and support the livelihoods and food security of almost a 1.3 billion people. The livestock sector is one of the fastest growing parts of the agricultural economy. Livestock is the world's largest user of land resources, with grazing land and cropland dedicated to the production of feed representing almost 80 % of all agricultural land (FAO 2010). Ethiopia is known by possessing largest number of live stock population ranking 9th in the world and 1st in Africa, however; animal disease is one of the most important constraints to increase the productivity of food animals in sub-Sahara Africa (Yilma2016)

The total population of camel in the world is believed to be 25.89 million, out of which 89% are one-humped dromedary camels (*Camelusdromedarius*) and the remaining 11% are the two-humped, *Camelusbactrianus* (FAO, 2013).Camels are the most numerous species of animal in the arid areas of Asia and Africa, particularly in the arid lowlands of east African counties (Sudan, Ethiopia, Somalia and Kenya, Djibouti) (Abera et al., 2015). In desert areas camel is a vital animal to daily life of people as a source of food, means of transportation, and most importantly its milk uses as medicine for diverse ailments (Kula and Tegegne, 2016). It plays a significant multi-purpose role in the dry lands of Ethiopia such as transporting of grain, water, salt and other goods as well as for milk and meat production. Additionally, camels are comparatively less susceptible to many of the devastating diseases that affect other livestock species, such as rinderpest, contagious pleuropneumonia and foot and mouth disease but yet they are affected by many other diseases (Kassa et al., 2011).

The most important and serious pathogenic disease of camel is Trypanosomosis, protozoal disease caused by *Trypanosoma evansi* parasite which has a wide range of distribution throughout tropical and subtropical regions of the world (Eyob and Matios, 2013). This vector born disease is higgly distributed arid areas of Northern Africa, East Africa, Asia and Arab emerates. Previously, case of camel *Trypanosoma evansi* was not reported in human but recently, first laboratory-confirmed case of *T. evansi* in human is reported in Southeast Asia (Chau et al., 2016).

Camel Trypanosomosis is most prevalent in Ethiopia (22%) and an important single cause of economic losses, causing morbidity of up to 30.0% and mortality of around 3.0% camels in Ethiopia (Abera et al., 2015). From two strains of T. evansi:type A and B;only type A strain is believed to be found in E thiopia while type B has been isolated only from Kenyan dromedary camels a decades ago. However, current study reported the isolation, genetic and phenotypic characterisation of type B *T. evansi* stocks from camels in Northern Ethiopia (Birhanu et al., 2016). Beside great economic losses caused by camel trypanosomiasis it's recently emerging as zoonotic disease and unexpected new strains of T.evansi are spreading to previosly free areas. Therefore the objective of this paper is to ststematically reviewing available documents on camel trypanosomiasis and to recommend further investigation on this area.

Historical Background and Zoonotic importance of Trypanosoma evansi in human

This trypanosoma was discovered in India more than a hundred years ago by Evans (1880), who detected it in horses, mules and camels with a disease locally called "surra". Subsequently, numerous reports of trypanosomiasis in horses and camels were recorded in North Africa, the Americas and Eurasia. Many different scientific names for the parasite were used, until it was found that all these non-tsetse transmitted. Trypanosoma is a genus of unicellular parasitic flagellate protozoa. Trypanosoma brucei species and Trypanosoma cruzi are the major agents of human trypanosomiasis; other Trypanosoma species can cause human disease, but are rare. But recent recent study in March 2015, a 38-year-old woman presented to a healthcare facility in southern Vietnam with fever, headache, and arthralgia. Microscopic examination of blood revealed infection with Trypanosoma furthermore, they declared first laboratory-confirmed case of *T. evansi* in a previously healthy individual without APOL1 deficiency, potentially contracted via a wound while butchering raw beef, and successfully treated with suramin. A linked epidemiological investigation revealed widespread and previously unidentified burden of *T. evansi* in local cattle, highlighting the need for surveillance of this infection in animals and the possibility of further human cases (Chau et al., 2016).

Etiology

Trypanosoma evansi is a species belonging to the subgenus Trypanozoon and is the causative agent of camel trypanosomosis. *T. evansi* is long slender trypanosomes with a prominent undulating membrane and long free flagellum (Abera et al., 2015). It is hypothesized that *Trypanosoma evansi* originated from *Trypanosoma brucei* by adaptation to a non cyclical mode of transmission and loss of ability to undergo growth and differentiation in the fly vector (Enwezor et al., 2005). Camels that came into contact with tsetse flies acquired infections, and when such camels moved to non-tsetse areas, transmission was spread by other haematophagous flies. Other species of trypanosomes, e.g. *Trypanosoma congolense*, *Trypanosoma brucei* and *Trypanosoma vivax* have also been isolated from camels in Sudan, but their role in camel trypanosomosis is insignificant(Elamin et al., 1999). Camel trypanosomosis is the most important single cause of morbidity and mortality in camels (Kassa et al., 2011).

Phatogenesis

Anaemia is a major component of the pathology of surra and of African trypanosomosis generally. Anaemia in *Trypanosoma evansi* infections of camels is reportedly macrocytic and hypochromic (Enwezor et al., 2005). In the early phases of infection the anaemia is haemolytic and haemophagocytic. The mechanism(s) responsible for this increased erythrophagocytic activity are not fully understood. Several have been proposed, viz, immune complexes, expanded mononuclear phagocytic system per se, haemolytic factor produced by the trypanosome, fever and disseminated intravascular coagulation (FAO,1979). In the late stages, anaemia continues to be a major factor, with probably additional causes. However, irrespective of the cause of anaemia the primary abnormality of function are the anoxic conditions created by the persistent anaemia. Following this are signs of dysfunction which appear in the various organs. An increase in cardiac output due to increases in stroke volume and heart rate and a decrease in circulation time are obvious manifestations. The central nervous system is reported to be most susceptible to anoxia with consequent development of cerebral anoxia. The marked depression observed in camel trypanosomosis is a mental state and is a manifestation of depression of cerebral cortical function in various degrees. Other nervous signs reported, such as circling movement, incoordination and dullness, appear to be the results of brain tissue disturbance or damage by the parasites. Evidence of *Trypanosoma evansi* being found in the cerebrospinal fluid has been presented (ROTTCHER et al., 1987).

Clinical sign

In camels the disease is manifested by elevation of body temperature which is directly associated with parasitaemia. Infected animals show progressive anaemia, marked depression, dullness, loss of condition, and often rapid death (Enwezor et al., 2005). In a typical case, the dromedary loses weight, develops a drooping hump, is unable to walk long distances, and may or may not develop oedema of the feet, brisket, underbelly and eyelids; the coat becomes rough. In the initial attack of fever there may be lacrimation, shivering, reduced appetite and mild diarrhoea. The animal always shows progressive anaemia and fluctuating body temperature with initial peaks of fever up to 41 °C. Later, the appetite is relatively unimpaired and the temperature may become normal or slightly elevated. Clinically it is manifested by weakness, lethargy, tachycardia, fever, pale mucosa, subcutaneous edema in brisket and eyelids, nasal and ocular discharges, abortion in pregnant camel and weight loss (Tadesse et al., 2015).

Diagnosis

Trypanosomiasis is diagnosed by demonstrating the parasite and tentatively can be diagnosed by owner's observations and clinical examination of camels in the field. The chronic form of trypanosomiasis is most

common in camel and may present an association with secondary infections due to immunosuppressant caused by *T. evansi* infection which may complicates clinical diagnosis (Luckins, 1992). The parasites can be detected in blood 13 to 16 days after an infective fly has had a meal to confirm infection. Parasitological diagnosis is mainly carried out by the direct microscopic examination of wet or stained blood films. However, the test has a poor sensitivity. One often less than 50% due to parasitaemia is intermittent. Post-mortem examination reveals no absolutely typical signs, but some degree of anaemia is often visible. Skeleton and heart muscles are pale, and there are signs of dehydration, pericardial effusion, enlarged lymph nodes and splenomegaly (OIE, 2013).

Life cycle and Transmission

Trypanosoma evansi is transmitted mechanically by haematophagous biting flies.

No developmental stage in a vector has been demonstrated which differentiates the parasite from *brucei.* Tabanids (horseflies) play the major role in transmission, while *Stomoxys* spp. and *Lyperosia* spp. may also transmit it. An interrupted feed upon an infected host leaves the fly hungry. Whenever it moves to another host, it can establish a new infection through its trypanosome-contaminated mouthparts. Trypanosomes remain infective on the proboscis for a short period only. The parasite replicates in camels, horses, donkeys, dogs, cattle, water buffaloes and even elephants. Equines and dogs are very susceptible and usually die after an acute course of the disease. Dogs may also become infected by eating meat from a trypanosome-infected carcass. Cattle, sheep, goats and antelopes often carry the parasite subclinically, acting as asymptomatic reservoirs (OIE, 2013).

Trypanosoma evansi cannot undergo growth and differentiation in the insect vector because it lacks the genes necessary for mitochondrial development (SONGA et al., 1990). It is transmitted mechanically by the bites of haematophagous fl ies, such as T*abanus* and *Stomoxys* (Kassa et al., 2011). Replication of the trypanosome occurs by longitudinal binary fission both in the host and in the vector with the flagellum and kinetoplast dividing together ((Liu-Liu et al., 2005).

Epidemiolgy

According to OIE (2013) *T. evansi* has a wide host range. In some countries incidence of surra increases significantly furing the rainy season when biting fly populations have greatly increased. Surra affects mainly camels and horses but buffaloes and cattle are also affected. Other species that develop severe disease include donkeys, mules, deer, llamas, dogs, cats, cattle and buffalo. Sheep, goats, pigs and elephants may occasional develop mild or chronic disease. Camel rising in Africa and buffalo production in Asia is severely affected. T. evansi is Pathogenic in most domesticated animals and some wild animals Domesticated animals: Horses, mules, donkeys, cattle, buffalo, camels (dromedary and Bactrian), llamas, pigs, sheep, goats, dogs and cats. It's most important single cause of morbidity and mortality in camels. Additionally, Wild animals: deer, capybara (reservoir host) and other species are susceptible. Further more new world camelids in South America are experimentally susceptible but natural disease has not been reported despite presence in cattle and horses. There are a reservoir host to camels and horses: cattle, buffalo, capybara, and vampire bat. Moreover, Rats and mice are highly susceptible as experimental hosts for detecting subclinical (nonpatent) infections

Distribution

Originally, the distribution of *T. evansi was restricted* to camel rearing areas but throudh time diseases were further disseminated by camel caravans traveling to North Africa, the Middle East and East and SouthAsia (*Abera et al., 2015).*In similar manner, horses were probably the means by which Surra reached America, principally by movement of the animals from West Africa in the 16th century (Enwezor et al., 2005).

Trypanosoma evansi is unique from other trypanosomes *because it* does not require the presence of flies (*Glossina* species) to ensure its maintenance as a result, it is widely distributed in areas far removed from tsetse infestation (Dia et al., 1997).The prevalence *Trypanosoma evansi* among camel herd is depends on the size of the vector population, rainy and wet season and swampycity (Mohammed, 1999).

The ability to be transmitted by blood-sucking insects other than Glossina, has enabled *T. evansi* to extend its range into African areas north of the Sahara desert, into Asia Minor, Pakistan, India, the USSR, China, Sumatra, Java, the Philippines, Mauritius, Madagascar, and South and Central America. It was introduced by camels into Australia, North America and South-West Africa (Eyob and Matios, 2013).

Table 1: prevalence of surra caused by Trypanosoma evansi in many countries of the world

country	Prevalence (%)	Type	reference
Jordan	33	*T. evansi*	Al-Rawashdeh et al., 2000
Sudan	33	*T. evansi*	Elamin et al., 1999
Niger	29	*T. evansi*	Pacholek et al., 2001
Kenya	28	*T. evansi*	Njiru et al., 2001
Nigeria	27	*T. evansi*	Enwezor et al., 2005
Mauritania	24	*T. evansi*	Dia et al., 1997
India	22	*T. evansi*	Radostits et al., 1994
Ethiopia	21	*T. evansi*	Zeleke and Bekele, 2001
Iran	10	*T. evansi*	Zarif-Fard et al., 2001
Chad	30	*T. evansi*	Delafosse et al., 2004
Saudi Arabia	*13.2*	*T. evansi*	*Hussain et al., 1991*
Pakistan	*10*	*T. evansi*	*Shah et a., 2004*
Morocco	*43.3*	*T. evansi*	*Rami et al., 2003*
Egypt	*65.9*	*T. evansi*	*El-Naga et al., 2016*

Treatment

Treatment of surra depends largely on four drugs: suramin, diminazene aceturate (Berenil), melarsomine (cymelarsan) and quinapyramine. Suramin and quinapyramine have been used for the treatment of *T. evansi* infection in camels, and only recently melarsomine (cymelarsen) was introduced for the treatment of surra in camels because of the problem of drug resistance. Most drugs are either not curative such as homidium bromide, or are too toxic for camels such as diminazene aceturate (Eyob and Matios, 2013).

Prevention and control

Surra is one of the most important diseases of camels. Camel rising in Africa and buffalo production in Asia is severely affected by surra. As in tsetse-transmitted trypanosomosis, losses are due to reduced productivity, mortality and cost of treatment. Control of surra can be difficult as there is no vector specificity and a wide range of hosts. Control of camel trypanosomosis involves parasite control and vector control. Treatment with trypanocidal drug is the usual method of control of *T. evansi*. This trypanocidal drug have curative and prophylactic role(aberra et al., 2015). *Sanitary prophylaxis:* Control measures are aimed at the host rather than vector, unlike Nagana Control measures include detection and treatment of infected animals, prophylactic treatment of susceptible animals, and protection of animals from biting flies and vampire bats.*Medical prophylaxis:* Drugs such as suramin, prothridium and isometamidium chloride (as a prophylactic) and diminazene aceturate (curative) can be used although drug resistance has been reported For camels melarsomine (cymelarsan) is very effective (curative) against *T. evansi* So far this drug is only registered for use in camels. No vaccines are available or likely in the near future because of the ability of trypanosomes to rapidly change their surface glycoproteins to avoid the immune response

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Current status of camel trypanosomosis in Ethiopia

Previously, T. evansi type A is the most abundant and found in Africa, Asia and Latin America while type B has been isolated only from Kenyan dromedary camels. But a recent study reported the isolation and the genetic and phenotypic characterisation of type B *T. evansi* stocks from camel inNorthern Ethiopia. According to this study, thirty cryopreserved buffy coat specimens from parasitologically positive dromedary camels were inoculated in immunosuppressed Swiss albino mice. In total, 22 parasite stocks originating from 22 different animals isolated and cryopreserved after 2 to 5 subpassages in mice. Then based on positivity in RoTat 1.2 PCR and EVAB PCR of the corresponding cryopreserved buffy coats, 20 of these stocks were T. evansi type A and 2 were T. evansi type B and they were labelled as MCAM/ET/2013/MU/01 to MCAM/ET/2013/MU/22 ((Birhanu et al., 2016).

In Ethiopia, the distribution of *T. evansi strain A* coincides with the distribution of camels in the semi-desert environment of the country. Surra in camel which caused by *T. evansi* is common in the southern, eastern regions of the country and rift valley areas (Table 2). This trypanosome also occurs in the dry country of the North West near the Sudan border and In Southern Ethiopia (Borena).

Cross sectional study conducted by Kassa and coworkers in Fantale district (dry season) to determine the prevalence of camel trypanosomosis and assess the distribution and dynamics of the vectors responsible for transmission of the disease reported overall prevalence of 4.4%, calves(less than 2 years of age) were negative and the high prevalence is recorded (7.7%) in young camels (between 3-4 years of age). A tendency of infection rate to increase with age this is mainly due to the fact of larger scale movement, which increases the risk of infection, by the adult camels than the younger (Tadesse et al., 2012).

Seasonal outbreaks of *Trypanosoma evansi* infections and the increase in number of *Tabanus occur*

during the rainy season. In this study, it is suggested that very few Tabanus were collected, which may probably be attributed to the low prevalence of *Trypanosoma evansi* in the study area during the study period. Additionally, according to these researchers the possible reason why calves were less infected than other age groups could be due to the fact that pastoralists keep them in the residence area and they do not go to distant areas where the fl y burden is high(NJIRU et al., 2002).

Table 2: prevalence of T.evansi in different areas of Ethiopia

Zones	*Prevalence (%)*	*Diagnosis* Technique	*Source*
Fantale	*4.7*	*MHCT*	*Kassa et al., 2011*
	4.4	*Blood smear*	
Tigray and Afar	*13.7*	*CATT*	*Birhanu et al., 2015*
Jijiga	11.7	PCR	*Tadesse et al., 2012*
	3.9	*Blood smear*	
Borena	*2.33*	*Serology:* ✓ thinsmear	*Olani et al., 2015*
Afar Region	*5.5*	*HCT*	*Aregawi et al., 2015*
	23.77	*CATT*	
Bale	*12.12*	*Parasitology:* ✓ BCM	*Hagos et al., 2009*
	24.88	Serology: ✓ CATT	
East Haraghe	*8.1*	*blood smear*	*Mohammed et al., 2015*

Another cross-sectional study conducted by to estimate the prevalence of camel trypanosomosis (surra) and identifying the species of trypanosome involved in Jijiga Zone reported overall prevalence of camel trypanosomosis as 3.9% and identified Trypanosoma evansi while higher prevalence of trypanosomosis is reported in adult camels (4.5%), and no young camel (0 to 4 years) found positive. study revealed that the prevalence of camel trypanosomosis was higher (4.49%) in adult compared to young camels. This finding is in a general agreement with Atarhouch et al. (2003), Gutierrez et al. (2000) and Dial et al. (1997) who reported that a tendency for infection rate to increase with age. This is mainly due to the fact of larger scale movement, which increases the risk of infection, by the adult camels than the younger

Study made by Olani and his collugues(2015) in Borena zone, southern Ethiopia to determine the prevalence of camel trypanosomosis (surra) and its associated risk factors reported the overall prevalence of camel trypanosomosis in the area to be 2.33 % and T.*evansi* is identified with laboratory examination. Additionally, significant prevalence difference among the surveyed districts is revealed as the highest prevalence, 12.2 and 10.6 % was observed in Cheri-leche and Magado-sake pastoral associations, respectively. Further more, the prevalence of trypanosomosis in female camels (2.51 %) is higher than that of male animals (1.77 %) but difference was not statistically significant. More over, this study reported that Camels residing in lowland areas, below 1000 m above sea level, exhibited a prevalence of 7.23 % which is higher as compared to those dwelling at elevated areas with altitudes of 1000–1499 and above 1500 m which showed prevalence rates of 1.9 and 2.14 %, respectively.

Another cross sectional study conducted on camel trypanosomosis in Dello- Mena and Sawena districts of Bale Zone Oromyia Region, Ethiopi comparing two areas of different ecological characteristics(wet and dry) reported the overall parasitological and serological prevalence of camel trypanosomosis as 12.12% and 24.88%, respectively(Hagos et al., 2009). But the recently, study at at the same area reported 17.9% prevalence of *T. evansi* (Abera et al., 2014).

Conculussion and reccomendation

Camel trypanosomosis is a disease of major economic importance in many countries in Africa, Asia and South America and now emerging as zoonotic as case is confirmed in human. A new strain of T.evansi type B is reported in Ethiopia. Accurate prevalence of T.evansi in Ethiopia is not yet known as disease reveals seasonal and geographical variations. In addition, difference in sensetivity to the different diagnosis techniques has a major effect on estimation of true prevalence. The chemo-therapeutic drugs in current use for the treatment of surra are toxic and problems of resistance are increasing.

So, in line with the above out lines the following reccomendations are forwarded:

- More sophisticated diagnostic techniques should be used in prevalence stimation and strain identification
- Care should be taken when managing clinically sick camel with trypanosomiasis since T.evansi is emerging as zonootic disease.
- Biology of the parasite and interaction whith host-pathogen should be studied for each specific

geographical area.

- The dynamics of mechanical transmission of camel trypanosomosis in endemic areas has to be thoroughly studied by including those factors contributing to occasional outbreaks

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