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Research Article

Prevalence and Risk Factors of Trypanosomosis in Dromedary Camels in the Pastoral Areas of the Guji Zone in Ethiopia

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Camel trypanosomosis is a life-threatening disease with adverse effects on camel health, production, and working efficiency. Despite this, camel trypanosomosis has received much less attention in Ethiopia compared with the disease in cattle and other animals. This cross-sectional study was conducted to evaluate the prevalence of camel trypanosomosis, identify the potential risk factors, and determine the importance of trypanosomosis in causing anemia in camels in the Gorodola and Liben districts in the Guji Zone of Oromia Regional State in Ethiopia. To this end, blood samples were collected from randomly selected 450 camels in heparinized capillary tubes and analyzed for the presence of *Trypanosoma evansi* using the buffy coat technique and Giemsa-stained thin smears. *T. evansi* infection was detected in 24 (5.3%) of the 450 camels examined. Out of the four variables analyzed in this study, two factors, such as body condition (BC) score and age, were found to be significantly ($P < 0.05$) associated with trypanosomosis in camels. A higher prevalence of trypanosomosis was observed in camels in poor BC (13.22%) than in camels in good (4.62%) or moderate (1.01%) BC. Likewise, adult camels (8.09%) were infected more frequently than young camels (1.12%), whereas no trypanosomes were detected in camel calves under 2 years of age. No significant statistical difference was found between the two districts, and male and female camels ($P > 0.05$). Statistically, the mean packed cell volume was significantly lower ($P < 0.05$) in parasitemic camels ($26.5\% \pm 7$) as compared with aparasitemic camels ($33.9\% \pm 9.1$). In conclusion, the current study conducted during a dry season showed a moderate prevalence of trypanosomosis in camels. Further studies using more sensitive and specific diagnostic tests, such as miniature anion-exchange centrifugation technique, serology, or molecular tests, are needed to establish a true epidemiological dataset on the prevalence and seasonality of the disease and its vectors in the study area to recommend viable control measures.

1. Introduction

Camels are vital domestic animals best adapted to the harsh environment and varied nutritional conditions of arid and extremely arid areas of Asia and Africa, particularly in the arid lowlands of East African countries, such as Sudan [1], Ethiopia [2], Somalia [3], and Kenya [4]. In Ethiopia's arid regions, camels perform various vital functions, including transporting items like grain, water, salt, and other goods, in addition to producing milk and meat for human consumption [5].

Due to the growth of desertification and range degradation, camels are already replacing other livestock in the pastoral areas of Ethiopia's Guji and Borena zones. Pastoralists are switching from cattle to camel and goats because they can thrive and produce under difficult environmental circumstances. Perhaps due to their capacity to thrive in harsh environments, camels were once thought to be resistant to many of the devastating diseases affecting other livestock species [6]. However, they still suffer from numerous diseases, including trypanosomosis [7].

Camel trypanosomosis, commonly known as surra, is the most important and serious pathogenic disease mainly caused by *Trypanosoma evansi*, which has a wide range of distribution in tropical and subtropical regions of the world [8–11]. *T. evansi* is transmitted mechanically by hematophagous flies

in the genus *Tabanus* and *Stomoxys* [9, 10]. In South America, transmission can occur through the common vampire bat, *Desmodus rotundus*, when it licks blood from an infected prey, usually horses or cattle [9, 10]. Oral transmission to carnivores when feeding on fresh infected meat or carcasses has also been described [12, 13]. Transmission can also be vertical, horizontal, iatrogenic, and per-oral, with various epidemiological significances, depending on the season, the location, and the host species [10]. The course of infection ranges from an acute disease with high mortality to a chronic infection characterized by subcutaneous edema, fever, lethargy, weight loss, abortion, nasal and ocular bleeding, immunosuppression, and limb stiffness [10, 14–16].

Trypanosomosis is an important cause of morbidity and mortality in camels in Ethiopia. According to the published studies, the prevalence ranges from 2% to 21% using standard parasitological diagnostic methods, namely, the microhematocrit centrifugation technique and examination of Giemsa-stained blood smears [17–24]. However, a prevalence of 23.77% was determined using a serological test [23]. Despite its impact on the health and production of camels, an animal that plays a significant role in the life of the pastoral community in the arid and semi-arid regions of Ethiopia, less attention has been paid to the disease compared with the disease in cattle and other domestic animals. Moreover, no documented information is available on the Guji zone, which is one of the agro-pastoralist areas with a large camel population.

Therefore, this study was conducted to estimate the prevalence of trypanosomosis, identifying the potential risk factors, and determine the importance of the disease in causing anemia in camels in the Gorodola and Liben districts in the Guji zone.

2. Materials and Methods

2.1. Study Area. This study was conducted in two selected districts, namely Gorodola and Liben from the Guji Zone of Oromia Regional State in southern Ethiopia. The districts were purposively selected on the assumption that, given their camel population and ecological conditions, they would represent the zone's camel-rearing districts. The districts have semi-arid and arid climatic conditions with lowland pastures, dry fields, and ponds suitable for the breeding of biting flies, such as Stomoxys and Tabanids, which serve as vectors for *T. evansi* (personal observations). Reports of high cases of camel trypanosomosis and the occurrence of the aforementioned vectors by the two district veterinary clinics were another reason for the selection of the districts for the current study. Two kebeles (the smallest administrative units) from each district were selected for the study. These are Nurahumba and Gofiyambo kebeles from the Gorodola district and Bulbul and Hadhessa kebeles from the Liben district.

Gorodola district is 565 km from Addis Ababa, the capital of Ethiopia. Geographically, the district of Gorodola lies between 4°56′15–5°48′00 North latitude and 39°43′00 –39°6′30 East longitude. Liben district is located in the extreme south of Guji Zone, 595 km from Addis Ababa. The district lies between 4°01′–5°451′ North latitude and 39°001′–40°001.8′ East longitude. The altitude of the Gorodola district ranges from 1100 to 1700 m above sea level, whereas that of Liben ranges from 750 to 1570 m above sea level. In terms of altitude, both districts are in the lowlands (Figure 1).

Both districts experience a bimodal rainfall, occurring from September to November (known locally as Hageya) and from March to June (known locally as Genna). Both districts have an average annual temperature of 25°C–27°C and a rainfall of 500–750 mm. The two districts are known for their natural forest to lowland grasses. Both districts are agro-pastoralist areas where cattle predominate, and the major rivers drained in the districts are Genale, Awata, and Dawa.

2.2. Study Population. The study population consisted of dromedary camels of all ages found and managed in agro-pastoral systems in the Gorodola and Liben districts. Sites, where camels gather for watering and browsing, were specifically chosen for camel sampling for the study. A total of 450 camels of different ages and both sexes were used for this study. All study animals were randomly selected from the camel population at grazing and watering sites.

The age of the animals was determined based on information provided by the owners. Camels under 2 years old were considered calves, camels between 2 and 4 years old were considered young, and camels over 4 years old were considered adults [25]. The camels' body condition (BC) was assessed visually and classified as poor, fair (moderate), or good. Sampling took place from December 2020 to March 2021, which is considered the dry season in the districts.

2.3. Study Design and Sample Size. This study used a cross-sectional study design, and the sample size required for the study was determined according to Thrusfield et al. [26] considering an expected prevalence of 50%, a confidence level of 95%, and an absolute precision of 5%. The formula used to calculate the sample size is described as follows:

$$n = \frac{1.96^2 \times P_{\text{exp}} \left(1 - P_{\text{exp}}\right)}{d^2}, \tag{1}$$

where n is the required sample size, P_{exp} is the expected prevalence, and d is the required absolute precision.

Based on the given formula, the calculated sample size was 384 but was increased to 450 to increase the precision of the prevalence estimate. The sample size was distributed proportionally between the two districts of Gorodola and Liben, with 200 and 250, respectively.

2.4. Sample Collection and Parasitological Examination. Blood samples were collected from each animal by ear venipuncture using a sterile lancet into a pair of heparinized microhematocrit centrifuge capillary tubes (75 mm × 1.2 mm). Each tube was filled with approximately two-thirds of its length and then sealed at one end with a crystal seal. The tubes were placed symmetrically on a microhematocrit centrifuge and spun at 12,000 rpm for 5 minutes. After centrifugation, packed cell volume (PCV) was measured using a hematocrit

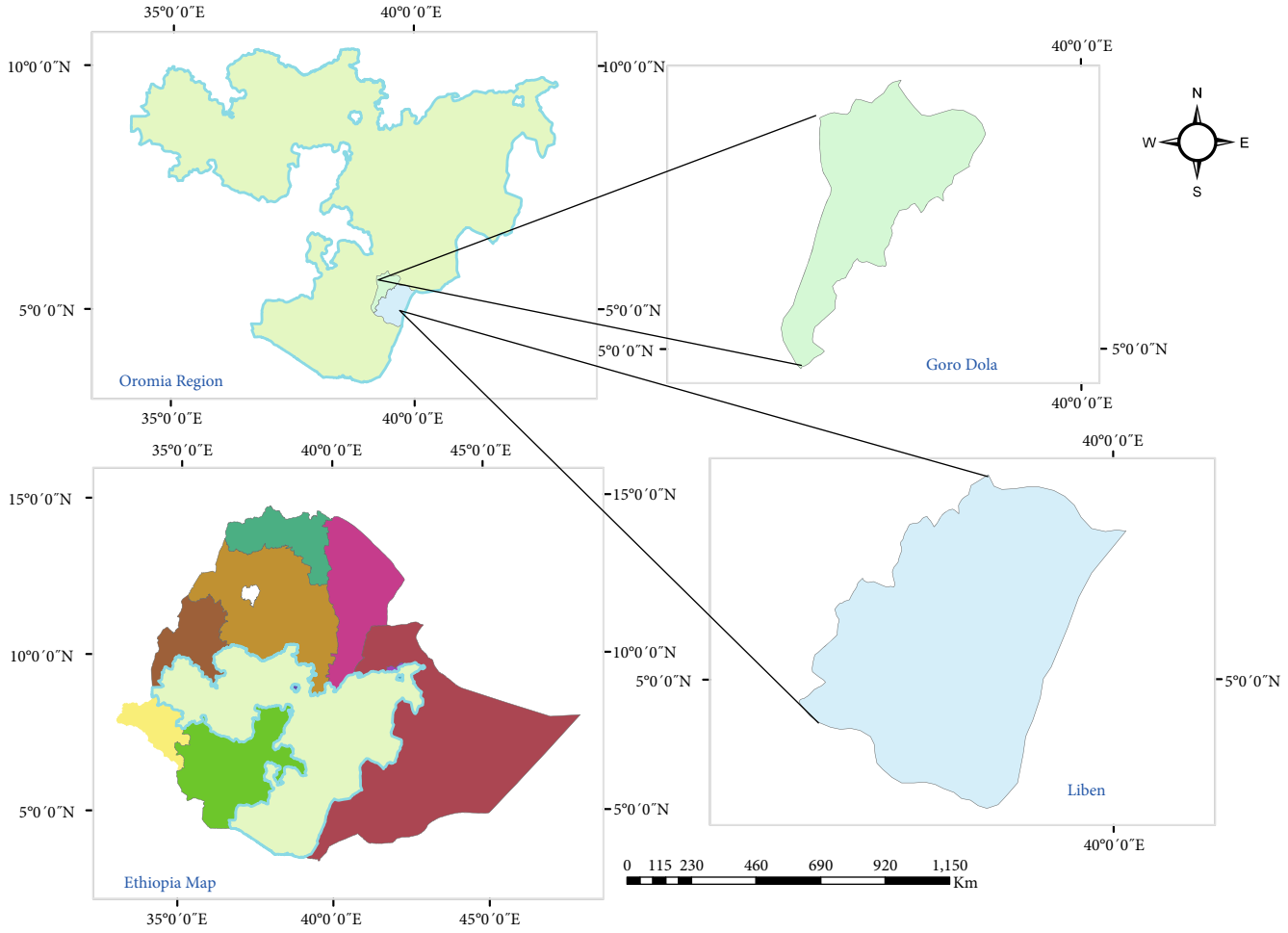

Figure 1: Map of Ethiopia showing the study area.

reader to determine the level of anemia. The capillary tubes were then cut using a diamond-tipped pen 1 mm below the buffy coat to include the top layers of red blood cells and 3 mm above to include the plasma. The contents were expressed onto a clean slide, mixed well, and covered with a 22 mm × 22 mm coverslip. Then, the wet smear was examined with an ×40 objective lens for the presence of motile trypanosomes [27]. Confirmation of trypanosome species was made by examining Giemsa-stained thin smears at ×100 magnifications [28]. In the blood smears, *T. evansi* was identified by its slender body, centrally located nucleus, free flagellum, prominent undulating membrane, and subterminal kinetoplast [8, 10].

2.5. Data Management and Analysis. Data collected from the study animals were recorded, filtered, and coded in a Microsoft Excel spreadsheet. Statistical analyses were performed with the Stata version 14.2 [29] and SPSS version 16 software programs [30]. The prevalence of trypanosomosis was calculated as the proportion of animals positive for trypanosomes in the parasitological examination divided by the total number of animals examined. The association of trypanosomosis with various potential risk factors, such as district, BC score, age, and sex of the animals, was analyzed using Pearson's chi-square test. Mann–Whitney *U* test was used to test for any statistical difference in the mean PCV between trypanosome-infected and uninfected camels during the study. A *P*-value <0.05 was considered significant at the 95% confidence level.

3. Results

3.1. Prevalence and Risk Factors. Of the 450 camels examined, 5.3% ($n = 24$) proved positive for trypanosomes in the microscopic examination of blood. Based on the sample district, the prevalence was 6% and 4.8% in Gorodola and Liben districts, respectively. Despite the higher prevalence of trypanosomosis in the Gorodola district than in the Liben district, there was no statistically significant difference ($P = 0.573$). Based on the morphological characteristics, *T. evansi* was the only species identified among the infected camels (Table 1). Male and female camels had a very close prevalence with no significant ($P = 0.877$) difference between them (Table 2). Adult camels over 4 years of age had a significantly ($P = 0.006$) higher prevalence of trypanosomosis than young camels between the ages of two and four years, whereas all calves examined were found negative for trypanosomes (Table 3). Camels with poor

Table 1: Prevalence of trypanosomosis in camels in Gorodola and Liben districts.

District	Number examined	Number positive	Prevalence (%)	95% CI	χ^2	P -value
Gorodola	200	12	6	3.4–10.3		
Liben	250	12	4.8	2.7–8.3		
Total	450	24	5.3	3.4–7.8	0.3169	0.573

Table 2: Prevalence of trypanosomosis in camels based on the sex of the animals.

Sex	Number examined	Number positive	Prevalence (%)	χ^2	P-value
Male	70	4	5.71		
Female	380	20	5.26	0.0238	0.877

BCs had a significantly ($P < 0.001$) higher prevalence compared with camels with good or moderate BCs (Table 4).

3.2. Packed Cell Volume. The mean PCV of all camels tested was 33.5%. Using the normal PCV range of 24–45% [31], 39.1% of trypanosome-infected and 9.1% of uninfected camels were anemic. The mean PCV was 26.5% in trypanosome-infected camels, whereas it was 33.9% in uninfected camels. Using the Mann–Whitney U test, the PCV difference between trypanosome-infected and uninfected camels was statistically significant ($P < 0.001$; Table 5).

4. Discussion

The current study found a 5.3% overall prevalence of camel trypanosomosis in the agro-pastoralist area of the Guji zone in Ethiopia. Compared with previous studies in Ethiopia using a similar diagnostic method, the current finding is above the reported prevalence of 2–4.5% [18–22] in different parts of the country, but comparable with the results of 5.15% [23]. The current prevalence, in contrast, is lower than earlier estimates of 21% in 2001 [18] and 10.65% in 2020 [24] in Ethiopia. When compared with studies outside Ethiopia using a similar diagnostic technique as the current one, it is lower than the prevalence reported in some countries including 7% in Sudan [1], 17.3% in Egypt [32], 14% in Algeria [33], and 7.5% in India [34], but higher than the prevalence of 0.7% in Pakistan [25], 2.1% in Iran [35], and 0.8% in Oman [36]. The differences in prevalence between the present and previous studies could be due to climatic changes, as these could have a direct impact on the distribution of biting flies, such as Stomoxys and Tabanids, which are responsible for the mechanical transmission of *T. evansi*. These vectors are known to thrive in environments with high humidity, high temperatures, and abundant vegetation [37, 38]. Studies have shown that the current climate change trend has increased the occurrence of *T. evansi* in different regions of the world. A study conducted in Ethiopia found a significant increase in surra prevalence in cattle due to changes in temperature and rainfall patterns [39]. Another study conducted in India reported similar findings, with higher incidences of *T. evansi* in regions with warmer temperatures [40].

In the present study, no statistically significant variation in the prevalence of camel trypanosomosis was found between the two districts used for the study. This might be the result of, among other things, similarities in the management system, vector abundance, accessibility to veterinary services, ecological settings, and animal owners' awareness of the disease. However, it is believed that further studies are needed to confirm this.

It was found that the prevalence of trypanosomosis varied significantly between age groups in this study, with adult camels older than 4 years showing a higher prevalence than younger camels (2–4 years), whereas no infection was detected in calves. As adult camels are mainly used for transport purposes, the higher prevalence in this age group may be caused by poor management and extreme stress from transporting products from one place to another, especially during harvesting periods, and other factors including reduced immunity, excessive exposure to the vectors, such as *Tabanus* spp. and *Stomoxys* spp. as they move and/or during grazing, and the existence of *T. evansi* reservoir hosts in the study area. In Africa, water buffaloes, camels, horses, and dogs have all been identified as reservoir hosts for *T. evansi,* with varying levels of susceptibility and potential for transmission [41–44]. This result is consistent with several previous studies in Ethiopia [20, 22–24] and elsewhere [45, 46], although a lack of significant variation was reported by others [21, 47]. The possible reason why calves in the present study were not infected by trypanosomes could be that pastoralists keep them in residential areas where there is no exposure to the vectors.

The present study showed a significantly higher prevalence of trypanosomosis in emaciated camels compared with camels in good or moderate BC status. Similar results have been reported in camels from Egypt [32] and Nigeria [48], although a study in Ethiopia reported a lack of significant association between infection and BC score [22]. Two different scenarios could account for the higher prevalence in poorly conditioned animals. The chronic form of the disease, which is the most common form, is characterized by severe widespread muscle atrophy and progressive loss of body weight [10]. The other possible justification for this is that the higher infection rate in poorly conditioned camels may be caused by lowered body defense brought on by nutritional stress or other infections, rendering them more susceptible to infection by *T. evansi* [49].

In the current study, no appreciable difference in the prevalence of camel trypanosomosis by gender was found. This needs to be confirmed in the future using proportionate numbers of both sexes, as the majority of the camels evaluated

Table 3: Prevalence of trypanosomosis in camels based on the age of the animals.

Age (years)	Number examined	Number positive	Prevalence (%)	χ^2	P -value
Calves (0–2)	97	0	0		
Young (2–4)	81	2	2.47		
Adults (>4)	272	22	8.09	10.9	0.004

Table 4: Prevalence of trypanosomosis in camels of different BCs.

BC score	Number examined	Number positive	Prevalence (%)	χ^2	P -value
Good	130	6	4.62		
Moderate	199	2	1.01		
Poor	121	16	13.22	22.4	<0.001

in this study—nearly five times as many as males—were females. Nevertheless, the present result is consistent with previous studies [11, 24, 43, 50]. In contrast to our study, Selim et al. [32] reported a significantly higher prevalence in female camels than in male camels. The authors attributed this to stress during pregnancy and lactation, which reduces female camels' resistance and makes them more susceptible to infection.

Although there have been reports worldwide that camels may be infected with tsetse-transmitted *Trypanosoma* spp. including *Trypanosoma simiae*, *Trypanosoma brucei*, *Trypanosoma congolense*, and *Trypanosoma vivax* [11, 51], based on morphological observations it is presumed that the species encountered in the current study is *T. evansi*. Consistent with this, reviews of camel trypanosomosis studies in Ethiopia indicated that *T. evansi* is the only species reported in all studies involving parasite identification [52–54].

In the current study, the mean PCV in trypanosome-infected camels was statistically significantly lower than that in uninfected camels. However, the mean PCV in both trypanosome-infected and uninfected camels was within the normal range of 24–45% [31]. According to Thrall et al. [31], the PCV range in camels moderately infected with trypanosomes is 24–40%, whereas it can be as low as 15% in those highly infected. The authors further stated that trypanosomal infection can lower PCV levels in camels, but even in these cases, the PCV remains within the normal range. This is because PCV can vary among individuals, and since the normal range is wide, it is still possible to find camels with PCV levels within the normal range, even if they are infected with trypanosomes [31]. Consistent with our study, a recent study in Egypt reported that the PCV levels of infected camels ranged from 33.6% to 42.3%, all of which were within the normal range [55]. This suggests that PCV levels alone are not a reliable indicator of trypanosome infection in camels. Additional tests, such as blood smear or polymerase chain reaction (PCR), should be performed to confirm infection. Nonetheless, the observation of a significantly lower mean PCV in infected camels in the present study is in agreement with earlier research on camel trypanosomosis in Ethiopia and other countries [23, 35, 51].

Table 5: Mann–Whitney U test results of mean PCV between trypanosome-infected and uninfected camels.

Infection status	N	Mean PCV (%)	Mean rank	Sum of ranks	U	P-value
Non-infected	419	33.9	226.9	95059.5		
Infected	23	26.5	123.6	2843.5	2568	<0.001

This study was limited by the use of parasitological diagnostic technique, which is less sensitive compared with serological and molecular methods. The parasitological technique used may have underestimated the prevalence of trypanosomosis in camels in the study area. In a study conducted in Somalia that combined parasitological, serological, and molecular diagnostic methods, all camels tested were negative for *Trypanosoma* spp. by the standard parasitological method, but 68.7% of the samples were seropositive for *T. evansi* by the card agglutination test (*CATT/T. evansi*). In addition to *T. evansi*, *T. simiae* was also detected in the molecular analysis [3]. Similarly, a higher prevalence of 37% for *T. evansi* was found in a Sudanese study using molecular technique, compared with 7% in Giemsa-stained thin smear. Furthermore, the study identified *T. vivax* as the second most common cause of camel trypanosomosis [1]. It is also not known whether the *T. evansi* circulating in camels in the study area is type A or type B or both, which could only be distinguished by molecular testing. Therefore, future camel trypanosomosis studies in Ethiopia need to consider more sensitive and specific diagnostic tests, such as miniature anion-exchange centrifugation technique, serology, or molecular diagnostic methods.

5. Conclusion and Recommendation

Using parasitological methods, the current study demonstrated a moderate prevalence of trypanosomosis in camels in the study area during the dry season of the year. The study also showed a significantly higher prevalence of trypanosomosis in adult and emaciated camels. Therefore, when employing disease management strategies in the current study area, the age and BC status of the camels should be considered, among other factors. The impact of climate change on *T. evansi* prevalence is a concerning trend that warrants further research and attention. As temperatures continue to rise and the weather patterns become more unpredictable, the risk of infection will likely continue to increase. Policymakers, researchers, and stakeholders must use one health approach to address this issue and develop strategies to mitigate its impact. To reduce the impact of the disease on camel health and production, proper diagnosis of the parasite and treatment with the most effective drugs, such as diminazene aceturate and isometamidium chloride, is recommended. Finally, awareness needs to be raised among camel owners to take preventive measures, such as vector control and regular deworming of their animals, as well as good parasite control to minimize the risk of infection. In addition, they should also be advised to provide proper nutrition and housing to keep their camels healthy.

Data Availability

All data used to support the findings of this study are included within the article.

Ethical Approval

This research was approved by the Hawassa University Institutional Research Ethics Committee. All methods are carried with the relevant guidelines and regulations. Before conducting the study, the objectives, expected outcomes, and benefits of the study were explained to the camel herd owners involved in the study, and oral informed consent was obtained from all camel owners.

Conflicts of Interest

The author(s) declare(s) that they have no conflicts of interest.

Authors' Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis, and interpretation, or all these areas; took part in drafting, revising, or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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