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Camel Trypanosomiasis "Dhukaan" in Lower Juba Region of Somalia: Importance and Microscopic Survey

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ABSTRACT

Camel trypanosomiasis is the most significant animal disease in the camel zone of Somalia. The Somali camel is also found in the southern areas of Somalia, which have a high density of vectors, including Glossina. The economic importance of camels in Somalia is well recognized; however, little is known about camel trypanosomiasis, especially in the southern part of the country. A cross-sectional survey was conducted from November 2022 to July 2023 to discuss the importance and prevalence of camel trypanosomiasis in the Lower Juba Region using interviews and blood films, respectively. A total of 126 blood samples from seven herds from three sites in Kismayo district were conveniently collected and microscopically screened for trypanosomes. The seven herders were interviewed for their awareness and the importance of the disease in the area. The overall prevalence was 4/7 (57.1%) and 13/126 (10.3%) at herd and individual levels, respectively. The mean PCV% of the infected camels was (24.85±5.87%) lower than the others (26.64±2.68) with a p-value of 0.053. Significant differences in the prevalence were reported between herds (p-value = 0.005), sites (p-value = 0.005), PCV% (p-value = 0.001), body conditions (p-value = 0.032), and mix-infection with other erythrocytic parasites (p-value = 0.019). Adopting a nomadic system, all the respondents were owners and men, and only one of them was unmarried. The Holy Qur'an was the level of education for all of them. Their knowledge about trypanosomiasis and its importance among other camel diseases, as well as their local names, was discussed. In conclusion, ranking third, camel trypanosomiasis is highly prevalent and moderately important in the region. Molecular studies on trypanosomes and tick-borne pathogens, as well as their socioeconomic importance, are recommended.

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INTRODUCTION

Occupying the Horn of Africa, the Federal Republic of Somalia (Somalia) includes six federal states, namely: Somaliland, Puntland, Banadir "Mogadishu", Hirshabelle, South West, and Juba Land. The economy of Somalia relies mainly on livestock, including camels **(Alary and Faye, 2016; Baumann and Zessin, 1992).** According to **FAO (2019),** the performance of livestock is undermined by a lack of state management post-1990s conflict and animal health care, including camels.

Somalia hosts the world's biggest population of the one-humped camel (*Camelus dromedarius*), and most of the Somali camels are female **(Hassan-Kadle *et al.*, 2019; Baumann and Zessin, 1992; Alary and Faye, 2016).** Camels in Somalia are all over the desert, including the southern areas of the country like Juba Land State, which have a high density of trypanosomiasis vectors, including *Glossina* spp. (the tsetse fly), as well as other haematophagous biting flies like *Tabanus* spp., and *Stomoxys calcitrans* **(Dirie *et al.*, 1989).** The livestock population in the Lower Juba Region of Juba Land State, Somalia, is about 3 million heads, including camels **(FAO, 2019)** and veterinary services and laboratory facilities are lacking in the region.

Trypanosomiasis, caused by *Trypanosoma* spp., is an insect-borne disease that affects animal production and human health in Africa and results in significant economic losses **(Angara, *et al.*, 2012; Eyob and Matios, 2013; Njiru *et al.*, 2000; Baumann and Zessin, 1992).** Both tsetse and non-

tsetse-transmitted trypanosomes were detected in camels in the camel zone of the continent (Fetene et al., 2021) including Somalia **(Hassan-Kadle *et al.*, 2019; Dirie *et al.*, 1989), and Sudan (Ismail *et al.*, 2015; Mossaad *et al.*, 2017).**

Trypanosoma brucei evansi (*T. evansi*), the main cause of camel trypanosomiasis (Surra), is one of the most significant veterinary issues in the world camel zone **(Nneka and Kojo, 2005; Eyob and Matios, 2013; Tehseen *et al.*, 2015).** "Surra", an Indian word meaning rotten, is a local name given to trypanosomiasis of camels and equines occurring in Africa, Asia, and Latin America, mainly due to *T. evansi* **(Soulsby, 1986; Nneka and Kojo, 2005; Eyob and Matios, 2013).** Then the disease is recognized with different local names in various endemic areas, such as "Guffar" in Sudan **(Karib, 1961; Soulsby, 1986)** and "Dukane" in Ethiopia **(Getahun, 2003).** The local name of the disease in Somalia is "Dhukaan" **(Moallin, 2021).** Cases of human *T. evansi* infection were reported in India and Vietnam **(Chandrapur, 2005; Joshi *et al.*, 2005; Shegokar *et al.*, 2006; Van Vinh Chau *et al.*, 2016).**

Fever, anaemia, hyperlacrimation, lower part oedema, poor body condition, and abortion were always reported as clinical signs of the disease **(Nneka and Kojo, 2005; Eyob and Matios, 2013; Gerem *et al.*, 2020; Njiru *et al.*, 2000; Zaitoun *et al.*, 2016).** After the insect bite, the parasites are found in the peripheral blood of the host (human or animal) and multiply by binary fission. Screening and early diagnosis of trypanosomiasis are helpful in taking appropriate actions to increase livestock performance **(Aregawi *et al.*, 2019; Desquesnes *et al.*, 2022; Nneka and Kojo, 2005; Njiru *et al.*, 2000).**

Although it is less effective compared to other diagnostic methods **(Desquesnes *et al.*, 2022; Nneka and Kojo, 2005; Hassan-Kadle *et al.*, 2019),** direct microscopic examination of Giemsa's stained blood films (GSBF) is the primary standard trypanosomiasis diagnostic method (STDM) **(Abdel-Rady, 2008; Gerem *et al.*, 2020; Njiru *et al.*, 2000; Tehseen *et al.*, 2015; Rafu *et al.*, 2021).** Microhaematocrit or buffy coat technique (BCT), serological, animal inoculation, and molecular diagnosis are also used for the diagnosis of trypanosomiasis **(Desquesnes *et al.*, 2022; Hassan-Kadle *et al.*, 2019; Mossaad *et al.*, 2017; Njiru *et al.*, 2000; Reck *et al.*, 2021; Tehseen *et al.*, 2015).**

According to **Aregawi *et al.*, (2019),** the global prevalence of *T. evansi* using direct microscopic techniques ranged from 2 to 9%. In the African camel zone, using direct microscopic technique, prevalence rates of 2.4, 3.9 to 8.1%, 4.5%, 2.5 to 7%, and 4.1 to 5.8% were reported in camels from Elgeria **(Boushaki *et al.*, 2019),** Ethiopia **(Gerem *et al.*, 2020; Mohammed *et al.*, 2015; Rafu *et al.*, 2021),** Kenya **(Njiru *et al.*, 2000),** Sudan **(Mossaad *et al.*, 2017; Ibrahim *et al.*, 2011),** and Egypt **(Abdel-Rady, 2008; Zaitoun *et al.*, 2016),** respectively. In the Asian camel zone, like Pakistan, a prevalence rate of 0.7% of camel trypanosomiasis was reported using GSBF **(Tehseen *et al.*, 2015).**

In Somalia, using microscopic techniques, a prevalence rate of 0.00%, 1.7%, and 5.3% was recorded in the most recent **(Hassan-Kadle *et al.*, 2019)** and previous research on camel trypanosomiasis **(Baumann and Zessin, 1992; Dirie *et al.*, 1989),** respectively. About 2.7% and 68.7% prevalence rates were reported from the samples of the recent author (**Hassan-Kadle *et al.*, 2019)** using molecular (ITS1-PCR) and serological (CATT/*T. evansi*) techniques, respectively.

The 1990s civil war in Somalia has resulted in low scores in some humanitarian indicators like education and research facilities, especially in the southern part of the country, like Juba Land State. Despite the known economic and social value of camels in the country, few publications are available about camel trypanosomiasis **(Hassan-Kadle *et al.*, 2019; Mohamed *et al.*, 2020)** and other camel diseases in Somalia **(Moallin, 2021; Ibrahim *et al.*, 2016; Hansen *et al.*, 1989).** Since Somalia hosts the greatest population of dromedary camels, camel trypanosomiasis is a serious concern for animal and camel production in the country **(Hassan-Kadle *et al.*, 2020; Hassan-Kadle *et al.*, 2019; Mohamed *et al.*, 2020).**

The disease in southern Somalia is not well documented. Therefore, the present cross-sectional study was conducted to obtain data about camel trypanosomiasis in the Lower Juba Region of Juba Land State, Somalia. The prevalence rate of the disease at the herd and individual camel levels was determined using a microscopic examination of GSBFs. Also, the herders were interviewed during the blood sample collection using a semi-structured interview form to discuss the herder's awareness of camel trypanosomiasis and the importance of the disease among other camel diseases in the Lower Juba region, Juba Land State, Somalia. Moreover, the local names of the diseases mentioned by the respondents were discussed and documented.

MATERIALS AND METHODS

Ethical approval

The study was approved by the ethical committee of Abrar University for data collection, analysis, and presentation. All participants were given oral forms in Somali. Participants were given the

right to refuse to take part in the study as well as to withdraw at any time during the study. Privacy and confidentiality were maintained throughout the study.

Study Area

Lower Juba Region is one of the three regions of Juba Land State in Somalia. The region lies in the depths of the Tsetse Belt (0.3560° S, 42.5461° E) in the southern part of Somalia. Kismayo is the capital of the region. The region is bordered by Kenya to the south, the Indian Ocean to the east, and the other two Juba Land State regions, namely, Gedo and Middle Juba, to the west and north, respectively. The region consists of six districts (Afmadow, Badhaadhe, Jamaame, Kismayo, Xagar, and Dhoobley). The human population in the Lower Juba region is 489,307 inhabitants, while the livestock population, including camels, is about 3 million heads **(FAO, 2019).**

Study population

Camel herders were interviewed about their awareness and the importance of camel trypanosomiasis among other camel diseases in the region. Their examined herds were categorized as small, medium, or big. Individual camels were examined for their body condition (good, poor, or extremely poor). The level of anemia and the presence of trypanosomes in their whole blood samples were microscopically examined in the laboratory. The sex of camels was observed and recorded, but the age factor was not included in this study.

Study design

A cross-sectional study was conducted between November 2022 and July 2023 to determine the prevalence of camel trypanosomiasis and its importance in the Lower Juba region of Somalia using the Giemsa's stained blood smear (GSBS) technique and semi-structured interviews, respectively.

Sample size determination

The formula ($n=z^2xpq/d^2$) of **Thrusfield (2005)** was used for sample size determination. The recent molecularly confirmed expected prevalence of 2.7% **(Hassan-Kadle *et al.* 2019**) and the level of confidence of 95% was used to calculate 41 camels as the minimum sample size as follows: $n=(1.96)^2*0.027(1-0.027)/(0.05)^2= 40.37$. The sample size was increased to 126 samples based on the convenience and the availability of camels and camel herds and to minimize the sampling error as well.

Sample design

Due to the absence of information about the population frame, ear tag, or camel's name, a nonprobability sampling technique was used. A total of 126 camels from 7 herds in three different sites (villages) in Kismayo district were conveniently examined for the presence of trypanosomes in their blood. Kismayo district was purposefully selected based on its camel population and security issues. The three examined villages (herds' sites) from Kismayo (Abaqbabaale, Kubo-Kibir, and Shandarmood) were conveniently selected.

Data collection

The herds' attendants during sampling were interviewed about their awareness, the importance, and ranking of camel trypanosomiasis among other camel diseases in the area using their brain-storming information. The local names of the mentioned camel diseases and their translation into English were documented using the manual of **Moallin (2021)** and personal communication **(Hassan-Kadle, 2023).** Data about the production system and the herd categories [small (1–10 heads), medium (11–20 camels), and big (>20 camels)] was collected during the interview. It was also recorded when the tested camel herd was mixed with other animal species. The individual camel's sex was noted, and the camel's body score was observed and scaled as 5 (good), 3 (poor), and 0 (extremely poor) during blood sampling. The age of the examined camels was not considered in this study.

After physical restraining, the jugular vein of each conveniently selected camel was disinfected with alcohol (ethanol) and punctured with a ten-ml syringe needle. About 5 ml of the blood was collected from each camel and placed in an Ethylene-Diamine Tetraacetic Acid (EDTA)-coated container for microscopic examination and anaemia determination. The thin blood smears were immediately prepared in the field, well labelled using a pencil, and fixed with methanol at the sample site. The thin dried and fixed blood films and the rest of the whole blood were transported in a cool box from Kismayo through Mogadishu airport to the Abrar Research and Training Centre (ARTC), Abrar University (AU), Mogadishu, for further laboratory work.

Laboratory work

The whole blood was used for the determination of anaemia using heparinized micro-haematocrit capillary tubes and a haematocrit centrifuge at 12,000 rpm for 5 minutes. Packed cell volume (PCV) levels of individual samples were recorded in percentages (PCV%) using hematocrit's reader.

The prepared thin, dried fixed blood smears were stained with 20% Giemsa's stain, dried, and checked for the presence of trypanosomes (Fig. 1)

using an electric microscope. Other blood parasites were reported when seen during the screening. The remaining whole blood samples were kept in a -20˚C deep freezer at ARTC, AU, Somalia, for further regional or international collaborative molecular research.

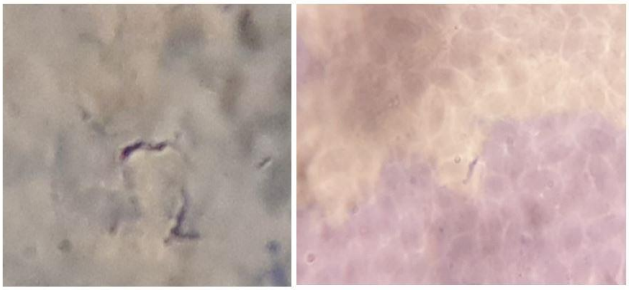

Fig. 1: Trypanosoma spp. in Giemsa stained blood film of camel from the Lower Juba region of Somalia

Data analysis

The collected data was checked, stored in Microsoft Excel, and transferred to a statistical package for social science software (SPSS) version 25 for frequencies, descriptive (t-test), chi-square test, and binary logistic regression analysis. For the prevalence rate at herd level, the herd was considered positive if a trypanosome was seen in the blood film (BF) of one of its camels. The differences between the examined variables were considered significant when the p-value is <0.05.

RESULTS

General findings

A total of seven herds were sampled from the three sample sites (villages) of the Kismayo district, including 3 herds (42.9%) from Abaqbabaale, 3 herds (42.9%) from Kubo-Kibir, and one herd (14.3%) from Shandarmood village (Table 1). All the investigated herds were large, ranging from 21 to 90 heads, mixed with sheep and goats (shoats), and one of the herds was mixed with shoats and cattle as well (Table 1). All seven herd attendants who participated in the interview during the blood sampling were the owners of the sampled herds, and all of them were men. The level of education of the participants is the formal centre of the Holy Qur'an. Their age range was between 36 and 62 years old, and only one of them was unmarried. All the examined herds adopted the nomadic husbandry system.

The total number of examined individual camels was 126, including 63 (50.0%) heads from Abaqbabaale sites, 41 (32.5%) heads from Kubo-Kibir sites, and 22 (17.5%) heads from Shandarmood sites (Table 1). The majority of the tested camels are females (93.8%), while the males are 33 (26.2%).

Table 1: General description of the camels examined for trypanosomiasis in Lower Juba region, Somalia

Sample site (Villages)	Herd level			Individual camel level		
	Herds	size	Mixed	Gender		Total (%)
				Female	Male	
Abaqbabaale	Herd1	67	Shoats	17	4	21(16.7)
	Herd2	83	Shoats	20	5	25(19.8)
	Herd3	41	Shoats	11	6	17 (13.5)
Subtotal(%)	3(42.9)	-		48(76.2)	15(23.8)	63(50.0)
Kubo-kibir	Herd4	21	Shoatsandcattle	6	3	9(7.1)
	Herd5	56	Shoats	12	7	19(15.1)
	Herd6	80	Shoats	7	6	13(10.3)
Subtotal(%)	3(42.9)	-		25(61.0)	16(39.0)	41(32.5)
Shandarmood	Herd7	90	Shoats	20	2	22(17.5)
Grant total	7(100)	-		93(73.8)	33(26.2)	126(100)

Prevalence of camel trypanosomiasis in the lower Juba region, Somalia

At the herd level, the overall prevalence of camel trypanosomiasis was 4/7 (57.1%). All three sampled herds (100.0%) at the Abaqbabaale sample site were positive for *Trypanosoma* spp., followed by the herds at the Kubo-Kibir site at 1/3 (33.3%). No trypanosome (0.0%) was demonstrated in the tested samples of the herd of Shandarmood village (Table 2). As presented in Table 3, the differences in prevalence between the herds were significant ($\chi 2 = 18.342$, P-value = 0.005).

At the individual camel's level, the overall prevalence of trypanosomiasis was 13/126 (10.3%). The prevalence in Abaqbabaale village was 12/63 (19.0%), and it was significantly higher (p-value = 0.005) than that of 1/41 (2.4%) in Kubo-Kibir and 0 (0.0%) in Shandarmood villages (Table 2).

Table 2: Prevalence of camel trypanosomiasis in the three different villages of Lower Juba region, Somalia

Village	Number		Prevalence (%)				P value
			Herd		camels		
	Herds(%)	camels(%)	p+ve	n-ve	p+ve	n-ve	
Abaqbabaale	3 (42.9)	63 (50.0)	3(100.0)	0 (0.0)	12 (19.0)	51 (81)	0.005
Kubo-kibir	3 (42.9)	41(32.5)	1(33.3)	2(67.7)	1 (2.4)	40 (97.6)	
Shandarmood	1 (14.3)	22 (17.5)	0(0.0)	1(100.0)	0 (0)	22 (100)	
Total	7 (100.0)	126(100.0)	4(57.1)	3(42.9)	13 (10.3)	113(89.7)	

Table 3: Microscopic prevalence of trypanosomiasis in camel herds from Lower Juba region, Somalia

Herds			N of camels tested		Prevalence n(%)			P value
					Herd	Individual camels		
Site	Herd	Size	N	%		p+ve	n-ve	
Abaqbabaale	Herd1	67	21	16.7	+ve	2 (9.5)	19 (90.5)	0.005
	Herd2	83	25	19.8	+ve	8 (32.0)	17 (68.0)	
	Herd3	41	17	13.5	+ve	2 (11.2)	15 (88.2)	
Kubo-kibir	Herd4	21	9	7.1	-ve	0(0)	9 (100)	
	Herd5	56	19	15.1	+ve	1 (5.3)	12 (94.7)	
	Herd6	80	13	10.3	-ve	0(0)	19 (100)	
Shandarmood	Herd7	90	22	17.5	-ve	0(0%)	22 (100)	
Total	7	-	126	100.0	4 (57.1)	13 (10.3)	113(89.7)	

As presented in Table 4, the prevalence rate was higher in female camels (10/93, 10.8%) than in males (3/33, 9.1%), with statistically insignificant differences (p-value = 0.542). The prevalence of trypanosome infection was significantly higher (p-value = 0.032) in camels with poor body condition (9/49, 18.4%) than in those with good body condition (4/77, 5.2%). The majority of the tested camels (95.2%) revealed 21-36% as a range of PCV%. Four out of the six (66.7%) anaemic camels with a range of PCV% (15–20%) were microscopically positive for trypanosomes, with a statistically significant difference (p-value = 0.001) in comparison to those positive 10/120 (8.3%) with an almost normal range (21-36%) of PCV% (Table 4). Tick-borne pathogens (TBPs) infection like piroplasms and anaplasma showed a significant (p-value = 0.019) effect on camel trypanosomiasis infection in comparison to camels that did not suffer from TBPs (Table 4).

The majority 77 (61.1%) of the examined camels were in good body condition, and 49 (38.9%) of them were in poor body condition. No one (0.00%) among the sampled camels was in an extremely poor body condition (Table 4). The overall PCV% of the examined camels ranged from 15 (minimum) to 36 (maximum), and their overall mean PCV% was 26.45±3.16%. The mean PCV% of the infected camels (24.85±5.87%) was lower than that (26.64±2.68) of the non-infected ones (p-value = 0.053). Six of the examined camels were in the PCV% range (15–20%) of anaemia (Table 4).

Table 4: Risk factors and prevalence of camel trypanosomiasis in Lower Juba region, Somalia

Factors		camel tested		Prevalence n(%)		χ^2	P value
		N	%	p+ve	95%CI		
Site	Abaqbabaale	63	50.0	12 (19.0)	10.3-32.4	10.471	0.005
	Kubo-kibir	41	32.5	1 (2.4)	0.1-12.0		
	Shandarmood	22	17.5	0 (0)	-		
Sex	Male	33	26.2	3(9.1)	2.3-24.8	0.073	0.542
	Female	93	73.8	10(10.8)	5.5-19.2		
Body condition	Good	77	61.1	4 (5.2)	1.7-12.5	5.615	0.032
	Poor	49	38.9	9 (18.4)	9.1-33.7		
	Very poor	0	0	0	-		
PCV%	15-20	6	4.8	4 (66.7)	21.2-100	21.619	0.001
	21-36	120	95.2	10 (8.3)	4.2-14.9		
TBPs	P+ve	91	72.2	13 (100.0)	8.0-23.8	5.575	0.019
	N-ve	35	27.8	0 (0.00)	-		
Total		126	100.0	13 (10.3)	5.7-17.2	-	-

The important significant variables ($p<0.05$) in the univariate analysis were further analyzed using binary logistic regression. The model was adequately fitted to the data by the Hosmer-Lemeshow test ($\chi2 = 2.299$, $p = 0.941$), and it showed that anaemia had a significant effect (p-value = 0.022) on the disease occurrence (Table 5).

Table 5: Binary Logistic regression (odd ratio) analysis of the risk factors of camel trypanosomiasis in Lower Juba region, Somalia

Factor	Category	Camel tested	P+ve (%)	OR(95%CI)	P value
Site	Abaqbabaale	63	12(19.0)	0.13(0.013-1.261)	0.078
	Kubo-kibir	41	1(2.4)		
	Shandarmood	22	0(0.0)		
Body condition	Good	77	4(5.2)	1.412 (0.336-5.927)	0.637
	Poor	49	9(18.4)		
	Very poor	0	0(0.0)		
PCV%	15-20	6	4(66.7)	0.096(0.13-0.717)	0.022
	21-36	120	10(8.3)		

Prevalence of other blood parasites detected in the blood film of the examined camels for trypanosomes in Lower Juba region, Somalia

A prevalence rate of 65/126 (51.6%) for other blood parasites like piroplasms (*Babesia* spp. and *Theileria* spp.) and a prevalence rate of 84/126 (66.7%) for blood bacteria like *Anaplasma* spp. were demonstrated in the red blood cells (RBCs) of the examined camels during microscopic field examination of the blood films for trypanosomes (table 6). All camels who presented trypanosomes in their blood films have either piroplasms or *Anaplasma* spp. mix infection, and 10/13 (76.9%) of the infected camels with trypanosomes have both piroplasms and Anaplasma in their erythrocytes.

Table 6: Microscopic prevalence of blood parasites in camels from Lower Juba region, Somalia

Parasite/organism	P+ve (%)	n-ve (%)	Total (%)
Trypanosoma spp.	13(10.3)	113(89.7)	
Piroplasms (*Babesia* spp. and *Theileria* spp.)	65(51.6)	61(48.4)	126(100.0)
Anaplasma spp.	84(66.7)	42(33.3)	
TBPs (Piroplasms + Anaplasma)	91(72.2)	35(27.8)	

The herders' awareness and the importance of camel trypanosomiasis in Lower Juba region, Somalia:

All the respondents (the herders' owners) declared that they knew about trypanosomiasis in camels, "Dhukaan," and mentioned the local name in the Somali language. They also know *Glossina* spp. (tsetse fly) "Dhuug" and *Tabanus* spp. (horsefly) "Baal" as the vectors of the disease. No one of them mentioned *Stomoxys calcitrans* (the stable fly).

The herds' owners considered camel trypanosomiasis a problem in the study area, and all of them rated it as a moderate problem among other camel health problems. During the interview, 5 (71.43%) of the herders ranked camel trypanosomiasis "Dhukaan" as the third important camel disease among other camel diseases in the Lower Juba region. One of the owners (14.29%) considered it number five, and only one herd owner (14.29%) ranked it as the first most important camel disease in the region (Table 7).

The respondents declared that they know when camels get infected with trypanosomes through clinical signs. Only one of them mentioned emaciation and anaemia, and the rest (6 owners) mentioned only emaciation as the main clinical signs of the disease. They know quinapyramine as the drug of choice for treatment. For the route of drug administration, based on their description, they use it intravenously instead of subcutaneously. The herders did not recognize if one of their camels had died due to trypanosomiasis in the study area.

Table 7*: The rank of camel trypanosomiasis "Dhukaan" among other camel diseases by herders from Lower Juba region, Somalia

Respondents (Herders)	Diseases
Herd1	Afdhur, Shimbir, Dhukaan, Hurdow, Taagow
Herd2	Qarar, Kud, Dhukaan, Shimbir, Afburbur, faje.
Herd3	Afdhur, Shimbir, Dhukaan, Hurdow, Taagow.
Herd4	Afdhur, Shimbir, Dhukaan, Kud, Hurdow, Taagow.
Herd5	Kud, Afburbur, Shimbir, Hurdow, Dhukaan, Tagow, Qarar
Herd6	Afdhur, Shimbir, Dhukaan, Kud, Afburbur, Taagow.
Herd7	Dhukaan, Dhuguto, Faje, kud, Qarar, Kadis.

*We placed the diseases in local names "Somali language" as they had been mentioned by the respondents and we listed the available names or meanings of these diseases in English in table (8).

Table 8: English Translation of the camel diseases mentioned by the respondents from Lower Juba region, Somalia

Local Somali name	English translation **(Moallin, 2021; Hassan-kadle 2023)**
Afdhur	Tetanus
Shimbir	Camel encephalitis
Dhukaan	Camel trypanosomiasis
kud	Anthrax
Af burbur	Camel contagious ecthyma
Qarar	Lymphadenitis
Kedis	Camel sudden death syndrome
faje	Wry neck syndrome, Bent neck syndrome, Torticollis
*Hurdow	Sleepiness
*Taagow	Stiffness
*Qarqarow	Shivering

*The translation of the last three diseases was not available in the manual of **Moallin, (2021)** and we get their meaning through personal communication with **Hassan-Kadle (2023).**

DISCUSSION

Camel trypanosomiasis is the most significant cause of economic losses in the camel zone of the globe, especially in East Africa. Somalia ranks first in the world's biggest population of the dromedary camel **(Alary and Faye, 2016).** Though few, most of the available research on camel diseases in Somalia was conducted before the civil war **(Baumann and Zessin, 1992; Dirie *et al.*, 1989; Hansen *et al.*, 1989).** Camel trypanosomiasis is the most significant animal disease in the camel zone of the globe, including Somalia **(Aregawi *et al.*, 2019; Fetene *et al.*, 2021). Hassan-Kadle *et al.*, (2019)** updated data about camel trypanosomiasis post-war in camels from the Banadir region (Mogadishu) of Somalia. The present paper discusses the microscopic prevalence and importance of camel trypanosomiasis in Lower Juba District, Juba Land State (the southern part of Somalia). In this study, all the investigated herds were large, and this is consistent with the fact that Somalia ranks first in camel population in the world **(Alary and Faye, 2016).**

All the examined herds in this study were found to be mixed with ruminants (sheep, goats, and cattle). This may increase the possibility of disease transmission to camels, including trypanosomiasis, due to *T. evansi* and other *Trypanosoma* spp. A high prevalence rate of different *Trypanosoma* spp., including *T. evansi*, was reported in ruminant cohered camels from Somalia **(Hassan-Kadle *et al.*, 2020)** and Sudan **(Mossaad *et al.*, 2020; Ismail *et al.*, 2015)** using microscopic and molecular techniques.

All the herds examined in this work adopt the nomadic husbandry system. The camel dairy farm system was reported by **Hassan-Kadle *et al.*, (2019)** and **Mohamed *et al.*, (2020)** during their camel trypanosomiasis survey in the Banadir region of Somalia. **Hassan-Kadle *et al.*, (2019)** stated that camels reared in a nomadic system were more likely to be seropositive for *T. evansi* than those under a dairy production system. Additionally, in agreement with the latter authors, the majority of our tested camels are females since males are always for sale in the norm with all animal species in the industry, as declared by the interviewed herders in the studied area.

According to the general health of our examined camels, no one was in an extremely poor body condition, and their overall mean PCV% was almost similar to the one reported during the camel trypanosomiasis survey in Sudan **(Ismail *et al.*, 2015; Ibrahim *et al.*, 2011).** In this study, the use of Giemsa's stained blood films (GSBF) instead of other STDMs like fresh wet smears and BCT was because of the lack of veterinary services and laboratory facilities in the studied area. It was available to prepare the blood films in the field and to continue the laboratory work in ARTC, AU, and Mogadishu.

The present paper reported one of the highest prevalence rates of camel trypanosomiasis using GSBF in herds (57.1%) and at individual camels (10.3%) in comparison to the results of those who use the same technique in Ethiopia **(Gerem *et al.*, 2020; Mohammed *et al.*, 2015; Rafu *et al.*, 2021),** Kenya **(Njiru *et al.*, 2000),** Sudan **(Mossaad *et al.*, 2017; Ismail *et al.*, 2015; Ibrahim *et al.*, 2011),** and Sudanese camels exported to Egypt **(Abdel-Rady, 2008; Zaitoun *et al.*, 2016).** Moreover, the actual prevalence rate of camel trypanosomiasis in the studied area may be higher than what was detected in the present work based on the undetectable classic chronic form of trypanosomiasis and the low sensitivity of the technique we used.

Using the same parasitological technique in Somalia, a lower prevalence rate was reported before the war of the 1990s **(Baumann and Zessin, 1992; Dirie *et al.*, 1989).** After that, camels from the Banadir region of Somalia showed no trypanosomes (0.00%) using STDM **(Hassan-Kadle *et al.*, 2019).** Furthermore, our microscopic prevalence rate of camel trypanosomiasis in Juba Land, Somalia, was higher than that (2.7%) reported by the latter authors when they rechecked their samples using molecular techniques. Excluding that the majority (73.1%) of the tested camels, according to **Hassan-Kadle *et al.*, (2019),** were dairy farm systems, our present findings indicate that trypanosomiasis is more prevalent in the southern part of Somalia than in the other regions of the country. This could be attributed to the more suitable environment for the vectors (Glossina and other biting flies) as well as the lack of veterinary services in the southern regions of Somalia due to security reasons. Additionally, based on the respondent's (herders) description, there is a misuse of drugs and drug administration. Moreover, in addition to *T. evansi*, we cannot exclude the presence of other tsetse and non-tsetse-transmitted trypanosome species in camels in the Lower Juba region. That is because our GSBF showed different sizes and morphologies of *Trypanosoma* spp.

However, the speciation of trypanosomes needs molecular confirmation. Even the fresh (wet) blood film microscopic technique can only confirm *Trypanosoma* vivax (*T. vivax*) through its characteristic movement. *T.* vivax was reported in camels from Sudan by **Ismail *et al.* , (2015)** and **Mossaad *et al.*, (2017)** using microscopic and molecular techniques, respectively. Together with *T. evansi*, *T. brucei*, *T. congolense*, and *T. simiae*, they had been reported in camels from Somalia

(Hassan-Kadle *et al.*, 2019; Baumann *et al.*, 1992; Dirie *et al.*, 1989). Moreover, about six different trypanosome species were molecularly confirmed in camels and other ruminants of the Banadir region of Somalia **(Hassan-Kadle *et al.*, 2019, 2020).**

In this study, statistically significant differences in prevalence rates were reported between herd size, sites, PCV% range, and the general body condition of the examined camels. Similar effects of camel trypanosomiasis on the PCV% of camels were reported during the trypanosomiasis survey in camels from Sudan **(Zaitoun *et al.*, 2016; Ibrahim *et al.*, 2011; Ibrahim *et al.*, 2010)** and Ethiopia **(Rafu *et al.*, 2021)** who reported insignificant effects of sex, age, or body condition on the infection. It is worth mentioning that the other blood parasites (TBPs) found in these camels can also cause anaemia **(Soulsby, 1986).**

In contrast to our risk factor findings, no significant differences in PCV% were found between infected and non-infected camels checked for trypanosomosis in Ethiopia by **Mohammed *et al.*, (2015),** who agree with us on the significant differences in the prevalence rate of camel trypanosomiasis between different areas. Also, **Gerem *et al.*, (2020)** and **Rafu *et al.*, (2021)** found no statistically significant differences in the occurrence of the disease due to area, herd size, and body condition categories in camels from Ethiopia.

Results are consistent with **Rafu *et al.*, (2021),** when there was no significant difference in the prevalence between male and female camels. In our study, the age factor was not included in the present paper, when many camel trypanosomiasis researchers **(Hassan-Kadle *et al.*, 2019; Rafu *et al.*, 2021)** reported no significant differences in the prevalence due to the different ages of camels using STDM.

In the present study, hyperparasiticemia of other blood parasites like Piroplasms (*Babesia* spp. and *Theileria* spp.) and blood bacteria like *Anaplasma* spp. was demonstrated in the RBCs of some examined camels during the microscopic field screening for trypanosomes. Piroplasmosis and anaplasmosis in camels were reported in camels from camel zones including the UAE **(Tigani-Asil *et al.*, 2021),** Sudan **(Abdelrahim *et al.*, 2009; Ibrahim *et al.*, 2017b),** and Somalia **(Ibrahim *et al.*, 2017a). Zaitoun *et al.*, (2016)** reported a hypertick infestation in clinically infected Sudanese camels with trypanosomes in Egypt. All the trypanosome-infected camels in this study were found to be mixed with either piroplasms or anaplasma, and most of the cases were infected with both of them. These kinds of infections, as well as camel gastrointestinal parasites **(Ibrahim *et al.*, 2016),** also cause anaemia.

The owners of the investigated herds in this survey declared their awareness and the importance of camel trypanosomiasis "Dhukaan" in the Lower Juba region of Somalia. They ranked the disease as a moderate problem and the third among other camel diseases in the region. The veterinary significance of Surra in the world camel zone was discussed by several authors **(Aregawi *et al.*, 2019; Fetene *et al.*, 2021; Nneka and Kojo, 2005).**

Our respondents declared that they know when camels get infected with trypanosomes through clinical signs (emaciation and anaemia). In some reports from Sudan, in addition to the clinical signs, owners check the odour of the camel urine to confirm camel trypanosomiasis **(Hussein and Gasmir, 1993; Elamin *et al.*, 1998).**

During the interview with the herders about the importance of camel trypanosomiasis, the present study uses the local names of different camel diseases, including camel trypanosomiasis "Dhukaan". The local name of the disease in Somalia looked the same as the local name "Dukane" mentioned in Ethiopia by **Getahun (2003).** That may be because camels from Ethiopia are concentrated in the Somali region of Ethiopia **(Alary and Faye, 2016; Eyob and Matios, 2013).**

CONCLUSION

It can be concluded that, the findings of this study revealed a high prevalence of trypanosomiasis in the southern part of Somalia, where not enough data was available about livestock diseases. The study also revealed information about the local names of camel diseases and the importance of camel trypanosomiasis among these diseases in the area. The study area is the richest agricultural and livestock-infested part of the country; therefore, further studies on the molecular characterization of camel trypanosomiasis and TBPs, as well as their socioeconomic importance, are recommended.

Conflict of interests

The authors declare no potential conflict of interest.

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