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Management of Camel Trypanosomiasis *(Surra)* among Pastoralists of Isiolo and Marsabit Counties, Kenya

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Abstract Camel trypanosomiasis or *Surra* is the single most important cause of morbidity and mortality in camels. The animals are kept under pastoral conditions often characterised by remote settings with poor infrastructure. These characteristics of pastoral areas do not attract either habitation or work of qualified veterinary service providers hence the camel keeping communities are left to play a major role to surmount any constraints that they encounter during animal husbandry. This paper presents management of camel trypanosomiasis, from an *emic* perspective, among camel keeping communities of Isiolo and Marsabit Counties. The information presented here within was collected in the above areas following field research activities undertaken in 2019. Results indicate that the communities were knowledgeable about the disease and majority rightfully associated camel trypanosomiasis with biting flies, the disease vector. The main symptoms observed for conclusion about *surra* to be made included loss of body condition, inability to walk long distances, rough hair coat, inability to feed well, reduced milk production in lactating females and abortion. The management of *surra* and its vectors among the camel keeping communities included use of both formal veterinary products and ethno-medicine. Drug stores (agrovets) were popular sources of veterinary drugs among the communities. The study recommends sensitization of the communities about use of veterinary drugs particularly those targeting camel trypanosomiasis and the disease vectors and, training of agrovet frontline staff to provide the desired information to herders as they buy drugs of their choice for effective disease management.

Keywords: *camel, trypanosomiasis, surra, isiolo, marsabit*

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1. Introduction

Camel trypanosomiasis or *surra* is a single most important cause of morbidity and mortality where the animals are kept [1,2]. The disease is caused by a protozoan parasite, the trypanosome (*Trypanosoma evansi*) and transmitted mechanically by biting flies, (the disease vector), of *Tabanidae* family between camels in Africa, Asia and South America [1,3,4]. In the affected communities, the disease negatively impacts on food and nutritional security and the general livelihoods [5,6,7]. The cost of treatment is also another pathway for economic losses to the camel keepers in particular and to the respective nations' economies in general [5].

Conventionally, management of *surra* and its vectors has been domiciled in chemotherapy and use of suitable acaricides respectively. The drugs used in formal treatment of *T. evansi* infection in dromedaries have largely included Suramin®, Cymelarsan®, Isometamidium chloride and Quinapyramine [8]. Other available trypanocides including drugs formulated to treat bovine trypanosomiasis such as Homidium bromide (Ethidium®) and pyrithidium bromide (Prothidium®) are either not curative [9] or some including diminazene aceturate (Berenil®) are too toxic to camels (9). The other form of disease management among camel keeping communities has been use of the age-long ethno-medical products that have included extracts from either leaves, roots or stems of medicinal plants and/or herbs locally available in local habitats of the communities (BioRI, unpublished field reports).

The effective use of chemotherapy and chemoprophylaxis largely depends on professional knowledge and relevant training. The Kenya's ASALs inhabited by pastoralists have been characterised by poor infrastructure with mostly rural settings. Privatization of veterinary services in Kenya in the 1990s resulted in inadequate professional veterinary service delivery in these ASALs, as most private veterinary service providers found it not economically viable to operate in these vast areas with poor infrastructure [10]. Whereas this had a negative impact on camel/livestock health and productivity following its preclusion of provision of veterinary services and dissemination of information on good camel health management practices to pastoralists [11], it has also left the choice to use acquired formal veterinary products and/or ethno-medical products to the individual camel herders. The result has been mushrooming of unskilled veterinary service providers (community-based animal health workers (CBAHWs)) and self-medication of livestock including camels [12]. The use of local knowledge on livestock drugs and absence of veterinary advice about disease and treatment options could potentially compromise the efficacy of treatments and contribute to the development of drug resistance [13].

This comparative cross ethnic study was carried out between November and December of 2019 to establish *emic* management practices associated with camel trypanosomiasis among five camel keeping communities of Isiolo and Marsabit Counties of Kenya's north-eastern ASALs. The specific communities in focus were the Somali, Turkana, Rendille, Borana and Gabbra. The main aim of the study was to discern any socio-cultural or locational influences on *surra* management. The cross cultural results presented here within are expected to open up discourses about the necessity of cultural relativism in the development of disease control packages particularly targeting vector borne diseases such as camel trypanosomiasis in the ASALs.

2. Materials and Methods

2.1. Study Area

This study was conducted in two counties namely Isiolo and Marsabit.

2.1.1. Isiolo County

Isiolo comprises of about 25,700 square km land size with a population of 268,002 people [23]. It is inhabited by five communities including the Ameru, Borana, Somali,Turkana and Samburu. The county is characterised by three main ecological zones namely semi-arid, arid and very arid zones. Rainfall amounts vary widely across the county, with lows of about 150-250 mm annually in the very arid areas, 300-350 mm in the arid areas, and about 400-650 mm in the semi-arid zones. There are two rainy seasons, short and long seasons. The short rain season occurs between October and December with the peak in November and, the long rain season occurs between March and May with the peak period being in April. Overall, the county experiences hot and dry temperatures in most months with temperatures ranging from 12°C to 28°C. The county's inhabitants are characterised by livestock production as an economic activity with pastoralism being the mode although some irrigation agriculture along seasonal rivers is also practised.

2.1.2. Marsabit County

Marsabit County covers an area of 66.923, square kilometres and is home to 459,785 people [23]. The county is inhabited by various ethnic groups including the Rendille, Gabbra Borana, Samburu and Turkana. It experiences semi-arid climatic conditions with an average temperature range of between 15°C to 26°C and annual rainfall that ranges between 200mm and 1,000mm per annum. Long rains start in April and May and short rain seasons are from November and December [22]. Pastoralism is also the main economic activity undertaken though agricultural activities including maize cultivation are also undertaken in areas around Mt. Marsabit

2.2. Sampling

The target population comprised the camel keeping communities of Isiolo and Marsabit Counties. These were the Borana, Somali, Turkana, the Rendille, and Gabbra. For every community, two villages (apart from the Turkana where one village was sampled) were purposively sampled based on accessibility and security (Table 1 and Figure 1a & Figure 1b). With the assistance of the local administration, a listing of all camel keeping households residing in the sampled villages was generated and all the available households on the list visited. Each of the selected household provided a responded, who was interviewed using a questionnaire that had been prepared and pre-tested earlier. The main targets were household heads but in the event the household head was unavailable, the next available senior most member of the household was interviewed. For every village, an enumerator with good local knowledge of the village and language was recruited and trained to administer the questionnaire under the supervision of the implementing scientists. The questionnaire had been designed to capture variables including background information (composing of demographic factors such as age, gender and years attained in formal education and other household characteristics), knowledge of the disease and its vectors; disease management and sources of veterinary products used in disease and vector management.

Table 1. Sampled Villages

Ethnic community	Sampled villages	County
Rendille	Loglogo Laisamis	Marsabit
Gabbra	Bubisa Turbi	
Borana	Gambella Kulamawe	Isiolo
Somali	LMD Kampi Garba/Mulango	
Turkana	Ngaremara	

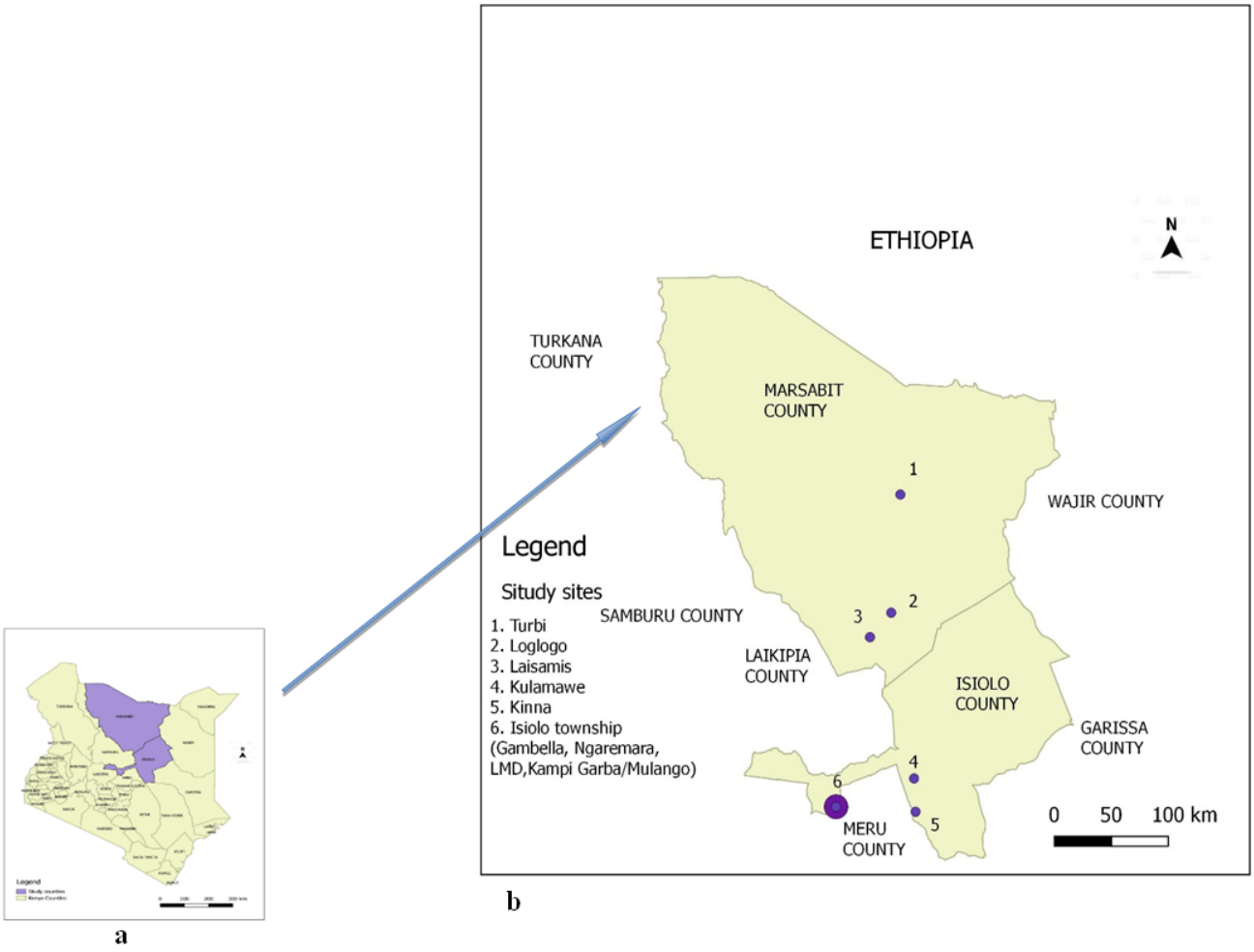

Figure 1. a, Map of Kenya indicating the research site; b: Map of Isiolo and Marsabit Counties indicating sampled villages (Source: GIS Lab, KALRO - BioRI)

For the purpose of this study, a household was considered as being a set of (related or unrelated) people habitually sharing the same dwelling (whether it was their main residence or not) and who had a joint budget. The habitual residence was the dwelling in which they usually lived. The household was, therefore, composed of people who shared the same budget, that is, those who contributed resources towards the expenses made for the life of the household and/or, members who merely benefited from those expenses. Information from completed questionnaires was stored in MS Access and analysed descriptively using SPSS Version 20.0. A simple cross-tabulation exercise was conducted in SPSS and variables of interest analysed to establish the resultant intra and cross ethnic scores. Data was presented in proportional and frequency tables.

3. Results

3.1. Characteristics of Camel Keeping Households

A total of 340 respondents in Isiolo and Marsabit counties were interviewed out of whom 111 were of Somali ethnic group, 41 Turkana, 35 Borana, 84 Gabbra and 69 Rendille. Table 2 summarises the key demographic characteristics of the respondents and characteristics of their households.

A majority, (84%), of household heads in all communities in focus were male. However there was also representation of women as household heads across the ethnic groups albeit to varying degrees. The Somali for example had a higher proportion (22%) of female-headed households while the lowest representation was among the Gabbra at 6%. The results further show that a large proportion (79%) of households heads had no formal education. The Somali and the Borana had a comparatively bigger proportion of household heads who attended formal education standing at 34% and 37% respectively, a majority of these heads having completed primary school level at 21.6% (Somali) and 14,3% (Borana). However, a gender analysis of the variable (formal education) presents a trend that indicates reductions in representation of the either gender as the level of education increased among the Somali, Borana and Turkana. A notable point that is observed is that the Gabbra and Rendille communities did not have women household heads with any formal education (Table 3).

Most of the households (64%) relied only on livestock keeping as the main source of livelihoods.

Table 2. Characteristics of households rearing camels

Parameter	Ethnic Group					
FREQUENCIES	**Somali (N=111)**	**Rendille (N=69)**	**Gabbra (N=84)**	**Borana (N=35)**	**Turkana (N=41)**	**Total (N=340)**
HH head gender: Male	88 (79)	57 (83)	77 (94)	29 (83)	33 (81)	284 (84)
Female	23 (22)	12 (17)	5 (6)	6 (17)	8 (19)	54 (16)
HH head formal Education: No	73 (66)	67 (97)	72 (88)	22 (63)	34 (83)	268 (79)
Yes	38 (34)	2 (3)	10 (12)	13 (37)	7 (17)	70 (21)
Production system used Agro-pastoral	7 (6)	0 (0)	0 (0)	0 (0)	2 (5)	9 (3)
Pastoral	104 (96)	69 (100)	82 (100)	35 (100)	39 (95)	329 (97)
Other sources of income None (only livestock)	58 (52)	52 (75)	55 (67)	25 (71)	26 (63)	216 (64)
Formal employment	2 (2)	0 (0)	2 (2)	1 (3)	5 (12)	10 (3)
Crop farming	7 (6)	0 (0)	0 (0)	0 (0)	1 (2)	8 (2.4)
Business	18 (16)	7 (17)	8 (10)	8 (20)	5 (12)	46 (13.6)
Others	26 (24)	13 (18)	18 (22)	12 (8)	4 (11)	60 (17)
*Numbers in brackets represent percentages.						
MEANS†						
Age of HH head (years)	54.8 (15.1)	52.9 (12.3)	55.5 (14.8)	47.6 (15.5)	46.6 (15.6)	52.9 (14.9)
Size of HH (number)	9.9 (4.4)	10.0 (5.5)	7.6 (2.7)	9.3 (3.7)	10.5 (5.1)	(4.4)
* Numbers in brackets represent standard deviation						

Table 3. Highest Formal Educational Level Attained

Ethnic Group	Highest Level Attained, Proportion and Gender					
	None	Lower Primary (1-4yrs)	Upper Primary (4-8yrs)	Secondary (9-12yrs)	Tertiary (13≥ yrs)	Total
Somali	73($54^{m}19^{f}$)	7($7^{m}0^{f}$)	24($20^{m}4^{f}$)	5($5^{m}0^{f}$)	2($2^{m}0^{f}$)	111
Turkana	34($30^{m}4^{f}$)	2($0^{m}2^{f}$)	3($1^{m}2^{f}$)	2($2^{m}0^{f}$)	0($0^{m}0^{f}$)	41
Borana	22($19^{m}3^{f}$)	4($3^{m}1^{f}$)	5($3^{m}2^{f}$)	3($3^{m}0^{f}$)	1($1^{m}0^{f}$)	35
Rendille	67($55^{m}12^{f}$)	0($0^{m}0^{f}$)	1($1^{m}0^{f}$)	0($0^{m}0^{f}$)	1($1^{m}0^{f}$)	69
Gabbra	74($69^{m}5^{f}$)	3($3^{m}0^{f}$)	4($4^{m}0^{f}$)	0($0^{m}0^{f}$)	3($3^{m}0^{f}$)	84
Total						**340**

*Figures in brackets represent scores disaggregated by gender; Superscripts (^{m})for male and (^{f})for female

3.4. Knowledge of *Surra*, Vector and Control Practices

All (100%) respondents from all communities placed camel trypanosomiasis (*surra)* among the top diseases that affected their camels. The local names of the disease were: *Ghandi* (Gabbra); *Umar/Gandi* (Rendille); *Dukan/Gandi* (Somali); Gandi (Borana) and *Lotorobwo/Lour/Lipis* (Turkana However, the term *Gandi/Gendhi* seemed to be the general reference for the disease in all the five communities under study. As far as the disease symptoms and signs were concerned, the respondents gave varying numbers of symptoms. However, the most commonly mentioned symptoms across the five ethnic groups included loss of body condition, rough hair coat, Inability to feed well, reduced milk production in lactating females and the *surra*-sick camels being unable to walk long distances. Table 4: below summarises the inter and intra ethnic frequencies and proportional scores related to mentioned perceived symptoms.

Table 4. Camel trypanosomiasis symptoms as mentioned by respondents across ethnic groups

Symptom	Ethnic Group					
FREQUENCIES*	**Somali (N=111)**	**Rendille (N=69)**	**Gabbra (N=84)**	**Borana (N=35)**	**Turkana (N=41)**	**Total (N=340)**
Mentioned symptom (No. mentioning the vector)						
Body Condition	95(85.6)	65(94.2)	79(94)	29(82.9)	40(97.6)	308(90.6)
Rough hair coat	86(77.5)	57(82.6)	70(83.3)	18(51.4)	30(73.1)	261(76.8)
Not feed well	86(77.5)	43(62.3)	65(77.3)	27(77.1)	26(63.4)	247(72.6)
Drop in milk production	77(63.4)	37(53.6)	55(65.4)	30(85.7)	26(63.4)	225(66.2)
Unable to walk	79(71.1)	50(72.5)	50(59.5)	19(54.3)	25(61)	223(65.6)
Abortion	76(68.5)	46(66.7)	55(65.4)	16(45.7)	19(46.3)	212(62.4)
Shivering	78(70.2)	30(43.5)	57(67.9)	20(57.1)	10(24.4)	195(57.4)
Sits down	75(67.6)	34(49.3)	33(39.3)	22(62.9)	29(70.7)	193(56.8)
Passing a lot of tears & saliva	70(63)	33(47.8)	30(35.7)	27(77.1)	30(73.1)	190(55.9)
Drooping hump	29(26.1)	39(56.5)	46(54.8)	5(14.3)	21(51.2)	140(41.2)
Swollen feet	58(52.2)	25(36.2)	20(23.8)	10(28.6)	20(48.8)	133(39.1)
Diarrhoea	48(43.2)	34(49.3)	18(21.4)	7(20)	14(34.1)	121(35.6)

*Figures in brackets are percentages

Most respondents associated the spread of the disease with presence of biting flies (including tsetse flies) and prevalence of such vectors was reported to be higher during the wet season. The proportion of camel keepers who reported to be applying insecticides to control these vectors was comparatively higher among Somali (Table 5). It is however important to note that whereas most (56%) Turkana and (57%) Borana camel keepers reportedly applied insecticide to control flies, a similarly significantly higher proportion (39%) of Turkana camel keepers made no effort to reduce host-vector contact. According to a key informants who also doubled up local administrators and camel keepers, the commonly used insecticides, by brand names were Ectopor®, Triatix® and Ectomin®.

Apart from use of insecticides to control the disease vectors, 12% of the respondents also used other methods. These methods included burning dung for the resultant smoke to act as fly repellent, positioning the animal housing in wind directions for the invading flies to blown away, moving animals to watering places during the middle of the day when hot and fewer flies active, avoiding wet and muddy places perceived to be breeding grounds for the flies and, treating wounds quickly before they became attractive to the flies (Table 5).

3.5. Treatment of Camel Trypanosomiasis (*surra)*

A majority of the respondents (78.2%) across the camel-keeping ethnic groups indicated having had animals that suffered from the disease. During the occurrence of the disease, trypanocidal drugs including Quinapyramin Sulphate (55.7%), Homidium Chloride (16.3%) and Isometamedium Chloride (1.5%) were used. The dosage mode was 10mls for young camels and 20mls for mature camels for the trpanocides. However, 21.8% of the respondents (from all the ethnic groups) with the Rendille leading with an intracommunity response of 53% followed by the Turkana at 35% used ordinary antibiotics including Oxytetracycline and Penstrep (Penicillin and Streptomycin) to treat their perceived trypanosomiasis sick animals. Use of ethno-veterinary products to treat the disease was also present but only among the Rendille at 21.3% of the respondents.

Whereas all the respondents from all the ethnic groups, apart from the Rendille, indicated that they did not use ethno-medicine to treat their last *surra* case, the question about whether the products were in use in the community was posed and responses indicated that 31.7% of respondents across the camel keeping ethnic groups were affirmative. Generally, about 10% of all those who treated their camels, with the drug of their choice, reported that they did not observe cessation of symptoms upon treatment. This proportion was higher amongst the Borana (23%) and 21% Rendille (Table 6).

Overall, the general ethno-medical products used included use of herbal products from different parts of different trees or shrubs, and to a limited extent use of tea leaves stirred in some water or sheep oil. The preparation of the above ethno-medical products involved crushing the parts or seeds in water and giving a litre of the filtrate to the perceived sick camels through oral administration. Settlements inhabited by the Rendille and Turkana showed comparatively high proportions of respondents with ethno-medical use.

The results further indicate that a majority, (63.2%), of respondents undertook treatment on their own, while (27.6%) were assisted by herders. Analysis across ethnic groups indicate that the Turkana, Rendille and Borana had high proportions of respondents who exclusively treated their perceived sick camels themselves without the assistance of trained veterinary officers standing at 90%, 70% and 66% respectively (Table 7).

Amongst those who treated their own animals as opposed to seeking veterinary aid, 155 (45.6%) indicated that they experienced some challenges such as death of camels following treatment, swelling of the injected sites, failure to recover, difficulty administering their drug of choice i.e. not sure about the site of administration (whether muscular or intravenous), inability to identify counterfeit products and, difficulty ascertaining the correct dosage.

Table 5. Number of camel keepers aware of *surra*, its vectors, seasonality and control

Item	Community orientation					
FREQUENCIES	**Somali (N=111)**	**Rendille (N=69)**	**Gabbra (N=84)**	**Borana (N=35)**	**Turkana (N=41)**	**Total (N=340)**
Identified vectors of surra (No. mentioning the vector)						
i. Biting flies	108 (97.3)	64 (92.8)	82(97.8)	35 (100)	40 (97.6)	329(98.8)
ii. Ticks	3 (2.7)	1 (1.4)	0 (0)	0 (0)	1(2.4)	5 (1.5)
iii. Mosquitoes	0(0)	1 (1.4)	0 (0)	0 (0)	1(2.4)	2 (0.6)
iv. Don't Know	0 (0)	3 (4.3)	1 (1.2)	0 (0)	0 (0)	4 (1.2)
Identified peak season for surra vector (No. mentioning the season)						
i. Rainy season	58 (70.3)	42 (61.8)	69 (84.1)	21 (60.0)	23 (56.1)	233 (69.1)
ii. Dry season	20 (18.0)	15 (22.1)	1 (1.2)	5 (14.3)	11 (26.8)	52 (15.4)
iii. All seasons	13 (11.7)	11 (16.2)	11 (13.4)	8 (22.9)	6 (14.6)	49 (15.5)
Key method for controlling surra vector (No. mentioning the method)						
i. Applied insecticide on animals	67 (62.6)	33 (48.5)	42 (50.0)	20 (57.1)	22 (56.4)	184 (55.3)
ii. Avoided infested areas	25 (23.4)	23 (30.3)	13 (17.1)	12 (34.3)	3 (7.7)	76 (22.8)
iii. Used other methods	9 (8.1)	2 (2.9)	15 (17.9)	3 (8.6)	11 (26.8)	40 (11.8)
iv. Did nothing	19 (17.1)	13 (18.8)	29 (34.5)	3 (8.6)	16 (39.0)	80 (23.5)

NB. The numbers in brackets represent the percentages.

Table 6. Experience with last case of *surra*

Item	Community					
FREQUENCIES	**Somali (N=109)**	**Rendille (N=67)**	**Gabbra (N=76)**	**Borana (N=33)**	**Turkana (N=40)**	**Total (N=325)**
Time last case of surra occurred in herd (Number mentioning the time)						
i. Within last one year	80 (73.4)	65(97.0)	63 (82.9)	24 (72.7)	22 (55.0)	254 (78.2)
ii. Between one and two yrs ago	17 (15.6)	1 (1.5)	8 (10.5)	3 (9.1)	5 (12.5)	34 (10.5)
iii. More than two years ago	12 (11.0)	1 (1.5)	5 (6.6)	6 (18.2)	12 (32.5)	37 (11.3)
Approach used to treat last case (Number mentioning the approach)						
Trypanocidal drugs	109 (100.0)	53 (79.1)	76 (100)	33 (100.0)	39 (100)	311 (95.7)
Ethno-veterinary approach	0 (0.0)	14 (20.9)	0 (0.0)	0 (0.0)	(0.0)	14 (4.3)
Name of drug used in treating last case and number scoring						
i) Quinapyramin Sulphate	60 (55.1)	15(22.7)	68(89.5)	18(54.5)	20(50)	181(55.7)
ii) Homidium Chloride	36(33)	1(1.5)	0(0)	10(30.3)	6(15)	53(16.3)
iii) Isometamedium Chloride	5(4.6)	0(0)	0(0)	0(0)	0(0)	5(1.5)
iv) Diminazen Aceturate	0(0)	1(1.5)	0(0)	0(0)	0(0)	1(0.4)
v) Others including antibiotics	8(7.3)	35(53)	8(10.5)	5(15.2)	14(35)	71(21.8)
vi) Ethnovet compounds	0	14(21.3)	0(0)	0(0)	0(0)	14(4.3)
Did the animal show full recovery after treatment						
Yes	96(87.0)	53 (79.0)	66(88.0)	27(77.0)	37(92.0)	279(85.8)
Response about Presence of ethno-veterinary products are available to help manage surra (Number mentioning presence)						
Yes	1(0.9)	50(74.6)	9(10.7)	7(20.0)	26(65.0)	93(31.7)
No	110(99.1)	17(25.4)	67(89.3)	26(88.6)	14(35.0)	242(76.4)

Table 7. Treatment of *surra* infected animals

Husbandry practice	**Orientation**					
	***Somali* (N=111)**	***Rendille* (N=69)**	***Gabbra* (N=84)**	***Borana* (N=35)**	***Turkana* (N=41)**	**Total (N=340)**
Who treats surra infected camels						
Trained Veterinarian	4(3.6)	10(14.5)	8(9.5)	0(0)	0(0)	22(6.5)
Animal Health Worker	1(0.9)	1(1.4)	1(1.2)	1(2.9)	0(0)	4(1.2)
Self	61(55)	48(69.6)	46(54.8)	23(65.7)	37(90.2)	215(63.2)
Other experienced herders	45(40.5)	10(14.5)	27(32.1)	10(28.6)	2(4.9)	94(27.6)
Others	0(0)	2(2.9)	0(0)	1(2.9)	2(4.9)	5(1.5)

*Figures in brackets represent percentages.

Table 8. Sources of *surra* treatment drugs

Main sources of surra drugs	**Ranks**				
	Somali	***Rendille***	***Gabbra***	***Borana***	***Turkana***
Agrovet shops	1	1	1	1	1
Open air markets sellers	2	2	4	-	4
Drug companies operating in mobile vans	-	-	-	4	3
Private sector veterinary personnel	4	4	3	-	2
Public sector veterinary personnel	-	3	2	3	-

3.6. Sources of *surra* Drugs and Treatment Services across Different Communities

Most (45.9%) of the respondents indicated that they obtained their veterinary drugs from specialised shops that sold agro-veterinary products (Agrovets). Other sources of veterinary drugs in the research site included open air markets, hawkers, drug companies and veterinary personnel in the area. However, inquiry about ranking of these sources indicated that respondents were in general agreement that agrovets were the most common and preferred sources of veterinary products in their respective areas (Table 8).

4. Discussion

Results indicate households in the research site constituted of both men and women as household heads. Decision makers in these households were thus composed of either men or women who held the position of household head. This implies that development projects or disease control strategies in these areas ought to be sensitive to representation of both men and women to have any sustainable impact.

Generally in this research site the results indicate the population had a high proportion of the members with limited formal education (21%) with the lowest proportion

recorded among the Rendille (3%). Majority of those with formal education attained primary level. This result has implications on form and pathway of communication, during need, particularly in the event that effective communication is to be developed. Population with low formal education attendance may require visual communication or photographic forms for effective propagation of Information, education and communication (IEC) mat particularly among the Rendille and the Turkana.

The dependence of the population across the ethnic groups on livestock as the main source of income and operating under challenges of pastoral setups increases camel herders' vulnerability to vectors borne diseases and the shocks resulting from climate change.

Results indicate that the population were knowledgeable about *surra* and its vectors. However, because the symptoms associated with the disease are non-specific, this increased the possibility of wrong diagnosis and treatment particularly given that most treatment of livestock diseases was done in the absence of qualified veterinary practitioners by the pastoralists themselves. According to [14], overuse and inappropriate use of common antibiotics leads to problems of microbial resistance among populations.

Whereas the respondents identified wet seasons as the peak period for the disease vector a proportion (15.5%) of population indicated presence in all the seasons. This confirms endemicity of the disease/ vector in the two camel keeping counties. Indeed a majority of herders indicated occurrence of *surra* within the past year. This result is also consistent with the findings of [15].

Although a majority, 55.3%, of the camel herders applied insecticides on their camels to manage biting flies, a sizeable proportion of the camel keeping population having no idea about what to do and others using traditional methods such as lighting fires to smoke the flies away and use of old engine oil indicates a struggle by the population to avoid the vectors. Even the herders that applied insecticides had a proportion of the respondents that used Amitraz, an insecticide formulated for control of ticks, to control biting flies. Whereas Amitraz is an acaricide, it is less effective against controlling of *surra* vectors. According [16], use of inappropriate vector control measures across communities, is an avenue that contributes to continuation of fly-host contact and thus contribute to endemicity of vector-borne disease load in affected areas. Where use of inappropriate vector control measures are observed, the need for training about effective vector control technologies among the population is demonstrated.

The finding about seasonality of presence of the biting flies is in agreement with previous studies on surveys of *Tabanus spp* in the various tropical areas that have shown a correlation between the seasonal outbreaks of *Trypanosoma evansi* infections and the increase in number of the flies during rainy seasons [15,17]. Rainfall and surface water pools also support the development of suitable camel browsing conditions, where acacia shrubs grow in abundance [4]. However, the response from a proportion of the respondents that they experienced flies all the time is also supported by [15] where they observed that in some areas, the prevalence of some *Tabanus spp*. is all the year round and thus ensures transmission of the parasite wherever reservoir hosts, vectors and susceptible hosts co-exist. The linkage of biting flies to the disease, seasonality and presence of the vector in all seasons as indicated by some respondents in all communities demonstrates the heavy *surra* burden borne by the camel keeping communities.

The most common and popular trypanocide used by the herders to treat camel trypanosomiasis in the two counties was Quinapyramine sulphate. Others included Homidium chloride and Isometamedium chloride. Whereas the above trypanocides were used, the use of veterinary products including ordinary antibiotics such as Oxytetracycline and Penicillin & Streptomycin by the sizeable proportion of herders to treat *surra* indicates need for training of herders on effective and prudent veterinary drugs use. The use of ethno-medicine to treat trypanosomiasis particularly among the Rendille necessitates evaluation to determine their efficacy against the disease for either promoting or clarification to the herders. The variation and lack of standardized dosage for the veterinary drugs including trypanocides against *surra* and other diseases among the communities under study also necessitates special focus for effective management of the disease. Indeed results indicate that some herders observed adverse reactions from their animals following treatment. The reaction could be due to use of wrong medication, improper dosing and/or unsuitable administration pathways. [3,8] note that improper use of drugs or needles may account for the observed post treatment problems. They further observe that the drugs used particularly for treatment of camel trypanosomiasis such as Isometamidium chloride when given intramuscularly produces severe local reactions.

Majority of the herders in the two counties mostly obtained their veterinary products from agrovet shops. The popularity of these drugs outlets is possibly due to the remoteness of some of the areas where veterinary officers do not have easy access or due to unregulated nature of the veterinary drug supply infrastructure. Whereas the drug supply outlets are important pathways that make the veterinary drugs available to the wider needy population, it may also be a conduit for introduction and sustenance of pathogenic resistance, against available trypanocides and ordinary antibiotics. This has the potential to make effective management of livestock diseases in these areas difficult.

Although the use of ethno-medical products was low (4.3%), it still attracts attention on the role it would play in the epidemiology of the disease were it found to be an ineffective approach. More importantly, even if there was no use of ethno-veterinary medicine in treating the last case of *surra* in other communities apart from the Rendille, in general, all communities reported the presence of such products. The use of ethno-medical products in management of *surra* and trypanosomiasis in livestock in general, particularly among pastoral communities, is a common occurrence [16].

Many studies touching on sources of veterinary medicine in pastoral communities have come to conclusions that drug stores, commonly known as agrovets are popular outlets for livestock drugs.

The use of agrovets as sources of veterinary products in pastoral communities has been widely reported by many

researchers including [11,12,18]. The high reliance on agrovets and other veterinary drug sources including informal open air markets and open street hawkers demonstrates the unregulated nature of access to these products. In the long run, this may exacerbate problems associated with quality of products and to a worst case scenario lead to pathogenic resistance to available veterinary product including trypanocidals.

Livestock disease management can further be complicated when self-treatment of perceived sick animals is done by herders themselves. The establishment by this study that self-treatment was a common occurrence in the research site is not a unique observation. [11,19,20] also had similar findings and attributed self-treatment by pastoralists to the nomadic nature of pastoral system and the disproportionate high expenses involved in transport and time involved in tracing camels and other livestock in these areas. [21] further note that many camel keeping communities including the Somali, Borana and Gabbra consider veterinary services from trained professionals to be only useful for cattle but not camels. They observe that pastoralists who also keep other livestock species apply their knowledge and experiences gained from their interaction with veterinary doctors and other trained officers on other livestock species and apply the same to camels. According to [21], the Borana have veterinary experience with their cattle that helps them to exploit available veterinary services for camels more frequently than the other pastoralists.

5. Conclusion and Recommendations

This study concludes that camel trypanosomiasis (*surra*) is an important disease of camel in the counties of Marsabit and Isiolo. The camel herders from these counties associated *surra* with biting flies as transmitting agents.

A majority of respondents used acaricides to control the flies although some respondents did not know what to do to keep the biting flies at bay. Whereas most of the respondents had knowledge about formal products used to control the vectors, some however, utilised other methods including using smoke, wind and used engine oil.

The most common symptoms used by camel keepers to identify *surra* included loss of body condition, rough hair coat, inability to feed well, inability to walk long distances and reduced milk production in lactating camels. Abortion also featured highly among the Somali, Gabbra and Rendille communities.

Most *surra* cases identified were treated using conventional trypanocidal drugs. In all the areas, dosage for either tryanocidal or antibiotics ranged from between 10ml (for young camels) and 20mls (for mature camels). The drugs mainly used for treatment of *surra* include Quinapyramine sulphate and Homidium chloride. However, ordinary antibiotics including Penicillin & Streptomycin and Oxytetracycline were used.

Apart from the above formal veterinary drugs, ethno-veterinary products were also in use with the Turkana and Rendille communities characterised by its usage.

Most of the respondents obtained their veterinary drugs from specialised shops (Agrovets) that sold agro-veterinary products**.** The agrovets were ranked as first among sources followed by open air markets that operate mainly on market days. Other sources of veterinary medicine in the research site included drug companies and government and private vets. The high reliance on the informal open air markets demonstrates the unregulated nature of access to these products. This may exacerbate problems associated with quality of products and pathogenic resistance to available veterinary products.

The treatment of sick camels was mainly done by household heads/owners and employed herders though male children also played a role. Decision making on the treatment of sick camels was done mainly by household heads across the five ethnic groups. Camel herders also played a role in the treatment, with the Borana, Somali and Turkana having a higher contribution of herder treatment. Other individuals who assisted in the treatment of camels include male children particularly among the Rendille. Respondents who treated their own animals as opposed to seeking veterinary aid experienced some problems including swelling of points of administration, failure to recover and at times and death of animals during or after treatment.

This study therefore makes the following recommendations:

1. The multiplicity of veterinary products that were in use against *surra* in the area, some of which were not trypanocidal in nature necessitates community sensitization about the more suitable products and their correct use.
2. Some respondents did not have any idea about how control biting flies in the area. This necessitates sensitization about fly control technologies/procedures to enable effective management among the camel keeping communities.
3. There should be basic training for agrovet attendants to provide suitable and relevant information relating to accessed/bought *surra* drugs and other products of veterinary importance.
4. Capacity building in identification and management of *surra* in the camel keeping communities in the counties should therefore, consider involvement of household heads, camel herders and sons in disease control programs.

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Statement of Competing Interests

The authors have no competing interests.

List of Abbreviations

IEC - Information, education and communication
CBAHWs - Community-based animal health workers
ASALs - Arid and semi-arid lands
BioRI - Biotechnology Research Institute

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