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A cross-sectional study on gastrointestinal parasitism in dromedary camel calves in Isiolo County, Kenya

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A cross-sectional study was carried out to determine the prevalence and risk factors associated with gastrointestinal parasitism in dromedary camel calves in Isiolo County, Kenya. Data on farm- and calf-levels were collected through semi-structured questionnaires. The calves were examined, and a faecal sample was collected per rectum for laboratory analysis. The gastrointestinal parasite eggs and oocysts were estimated using the faecal floatation and McMaster methods in the laboratory. Descriptive analysis was used to summarize the variables, and multilevel mixed-effects logistic regression models were used to explore the association between helminth infection and the farm- and calf-level risk factors. A total of 308 calves in 25 households were recruited for this study. The mean number of calves per herd, age and weight were 38, 7.3 months and 169 kg, respectively, while the age at weaning was about 11 months. The overall prevalence of gastrointestinal parasitism was 42%, while that of nematodes and coccidia were 31 and 3.9%, respectively. In the first model, the factors that were significantly associated with nematode infections were total milk yield per day, calf age, and calf weight. In the second model, the factors that were significantly associated with Nematodirus species infection were the age of the calf, live body weight and average weaning age of the camel calves. The study concludes that gastrointestinal parasitism (especially nematodes) occurs in camel calves in Kenya. It is recommended that the pastoralists should be educated on the impact of gastrointestinal parasitic infections in camel calves, and the importance of strategic deworming.

Key words: Helminths, coccidia, camel calves, prevalence, Isiolo, Kenya.

INTRODUCTION

The dromedary or one-humped camel (*Camelus dromedarius*) is the largest member in the camel family and accounts for over 95% of the whole population of Old World Camels, which are found mainly in Africa and Asia (Sazmand et al., 2019; Dioli, 2020). Camels are adapted to the harshest environments on Earth, especially hot

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deserts and are used for milk, meat production, transportation, social status and tourism (Al Abri and Faye, 2019).

There are several constraints that affect camel production, which include infectious and production diseases, gastrointestinal parasitism and availability of feed and water (Schwartz and Dioli, 1992; Faye et al., 2001). Helminths and coccidia infection affect camel production in all parts of Kenya, and the impact is more pronounced in calves of all ages, especially during periods of drought and food shortage (Ikiror et al., 2020) and thus it is important to determine the burden of these infections. Several gastrointestinal helminths and coccidia infect camels and are responsible for the major impacts on productivity and mortality in camel calves (Parsani et al., 2008). In Kenya, several studies have documented the various helminths and coccidia genus and species affecting camels. Helminthic infections of camels include specific nematodes such as *Haemonchus longistipes, Nematodirus mauritanicus, Nematodirus dromedarii* with the *Haemonchus* species causing the biggest impact on productivity (Wernery and Kaaden, 2002). Other nematodes that affect camels also affect other domestic animals such as sheep and goats and these include, *Trichostrongylus prololurus, Trichostrongylus vitrinus, Ostertagia mongolica, Marshallagia mentulata, Nematodirus spathiger* and *Oesophagostomum venulosum* (Banaja and Ghandour, 1994; Parsani et al., 2008; Wernery and Kaaden, 2002). Among gastrointestinal protozoan parasites, *Eimeria* spp. is a major problem in camels. Five *Eimeria* spp. have been reported to infect camels and these include: *E. cameli*, *E. pllerdyi, E. bacteriani*, *E. dromedarii* and *E. rajasthani* (Wernery and Kaaden, 2002; Yakhchali and Athari, 2010). Infection with these helminths and protozoan species are associated with diarrhoea syndromes and the impact on productivity depends on the nutritional and immune status of the camel (Parsani et al., 2008). Malnourished adult camels and the calves are the most affected, with symptoms such as diarrhoea and dysentery being very prominent (Fowler, 1996; Parsani et al., 2008). Other signs include dehydration, rough hair coat, and pale mucous membranes and, if very severe, lead to death, especially in young camel calves (Parsani et al., 2008).

The commonly used methods for the control of helminths and protozoan parasites include strategic and/or regular deworming and early treatment of diarrhoea cases with anti-protozoan drugs and grazing management such as rotational grazing (Singh, 2006; Wadhawa et al., 2011; Radfar and Aminzadeh, 2013; Pawar et al., 2019). There is scanty information on the occurrence of gastrointestinal infections/parasitism in Kenya, especially among the camel calves. This justifies the need to undertake the study on endoparasite prevalence and the associated risk factors in camel calves. Therefore, the study was designed to determine the prevalence and risk factors associated with gastrointestinal parasites in camel calves reared in Isiolo County of Kenya.

MATERIALS AND METHODS

Description of the study area

The study was carried out in Isiolo County, a typical Arid and Semi-Arid Land (ASAL) area in the lower northern eastern region of Kenya. The county covers an area of about 25,382 km^2 with a total human population of 268,002 individuals (Kenya National Bureau of Statistics, 2019). Geographically, Isiolo County lies between 0˚ 21' South and 37 ˚ 35' East and the altitude is between 170 and 1,100 m above sea level. The main livestock species in Isiolo County include camel, goats, sheep, cattle, donkeys and poultry. The camel has gained popularity recently, and the change has been brought about by the camel's resilience, increasingly frequent and severe droughts resulting in limited pasture and water resources, and new economic opportunities especially increased in demand for camel meat and milk. The estimated camel population in Isiolo County is about 148,859 animals (Kenya National Bureau of Statistics, 2019). In Isiolo County, the camel-keeping households are mainly from the ethnic backgrounds of Somali, Borana, Garre, Samburu and Turkana. Isiolo County is also home to some globally renowned wildlife conservancies with a significant population of free-roaming wildlife and human-animal-wildlife interactions.

Study design and selection of study site

This was a cross-sectional study that was carried out in July and August 2021 in which camel herds were visited once, and camel calves below two years of age were sampled and examined for gastrointestinal parasites. Four administrative wards were purposively selected based on the availability of camel herds, security situation, proximity to Isiolo town (for laboratory processing) and accessibility. Since the farmers practice pastrolism, camel herds within a selected administrative ward were identified with the help of administrative officers and Veterinaires Sans Frontieres (VSF) Suisse Kenya staff who contacted the registered farmers through phone communication.

Sample size calculation

Considering an eighty percent point prevalence (Mukhwana and Mitema, 1995) of nematodes, 95% level of confidence, power of 80 and 5% error of estimation, a sample size of 246 was computed using the formula described by Dohoo et al. (2009). The estimated sample size was enhanced to 308 to improve the power.

Data collection

Data on household- and calf- levels were collected through semi-closed questionnaires that were administered to household members or someone familiar with the animals. Questions on respondent demographics and household characteristics were asked. Such data included gender, age, education level, family size, land ownership, camel herd size and general camel husbandry. Calf characteristics and management practices were also captured. The camel calf details included sex, breed, age,

body condition score, heart and abdominal girth, shoulder height, weaning status, faecal consistency, lymph node swelling, deworming frequency, grazing practice and mineral supplementation. The live weight was estimated as live body weight (Kg) = -100.6 + 101.2AG (m) + 58.2 HG(m) + 9.91SH(m) where Heart girth (HG), abdominal girth (AG) and shoulder (wither) height (SH) measurements were used as described by Wanyoike et al. (2010). The body condition score was assessed by palpation and observation of the anatomic features, mainly (a) visibility of coxal, ischial and shoulder tuberosity, (b) visibility of ribs and vertebra and (c) hollow of the flank, and (d) depth of the recto-genital zone under the tail. The classes of body condition scores were categorized into four scores that included score 1 (very thin), score 2 (thin), score 3 (good) and score 4 (fat camels) (Faye et al., 2001).

Selection of calves and sample collection

To identify camel calves to be sampled, herders were asked first to identify all the calves less than two years of age then all calves were confined together and then restrained one at a time for health assessment and fecal sampling. Initially, vital parameters were measured, followed by other health parameters. Then, approximately 10 g of faecal samples were collected per rectum via digital extraction using lubricated gloves and put into faecal collection containers. The faecal samples were then put in appropriately labelled faecal containers and immediately kept in cool boxes packed with frozen icepacks and transported to Isiolo County Veterinary Laboratory for processing.

Parasitological analysis

Once in the laboratory, the faecal samples were examined using standard faecal flotation and McMaster egg count technique as described by Foreyt (2001). Briefly, a saturated salt solution was obtained by adding 400 g of NaCl to 1,000 mL of distilled water. This was followed by mixing 1 g of faecal material with 15 mL NaCl solution. The mixture was then filtered with a dry pad on a strainer, and the suspension was immediately transferred to a 2-chamber McMaster counting slide by filling both chambers. After 5 min, the loaded McMaster slide was observed under a light microscope. Helminth eggs and protozoa oocysts were identified morphologically when present (Foreyt, 2001). To determine the intensity of infection, the number of nematode eggs counted on both grids were recorded and multiplied by 50 to calculate the number of eggs per gram of faeces (Foreyt, 2001). The counts were expressed as eggs per gram (EPG) of faeces for helminths and oocysts per gram (OPG) of faeces for coccidia (Gupta and Singla, 2012).

Data management and analysis

Data from the questionnaires and laboratory results were entered into Microsoft Excel 2010, cleaned, coded, and imported into Stata 15.1 software. Descriptive analyses were first done by computing proportions for categorical variables and mean, median, standard deviation and range for the continuous variables. The apparent prevalence of nematodes and coccidia infection were determined as the proportion of positive (epg/opg>0) samples from the total samples examined.

A multilevel mixed-effects logistic regression analysis was performed to identify risk factors associated with nematode and *Nematodirus* species infection. In the first step, univariable regression analysis for all the predictor variables (due to their potential association with the outcome) were fitted into separate models to determine their unconditional associations with the presence of nematodes (*Strongyloides* spp, *Strongyle* type or *Nematodirus* spp) and *Nematodirus* spp only as separate models. In the second step, multivariable logistic regression analysis was fitted for all the univariable associations with $p \leq 0.3$ as guided by Dohoo et al. (2009). To begin with, correlations between predictor variables were evaluated using pair-wise correlation and one of the collinear variables was dropped (based on biological relationships). The final models for both nematodes and *Nematodirus* spp were fitted manually through backward stepwise removal of variables with the least statistical significance while retaining variables with $p \leq 0.05$. Plausible biological interactions between significant explanatory variables in the final model were also tested (Dohoo et al., 2009).

The area under the curve (AUC) of the receiver operating characteristic was used to evaluate the overall model performance.

RESULTS

Household demographics and animal characteristics

The household demographics and other farm and animal characteristics are shown in Tables 1 and 2. A total of 308 camel calves from 25 herds were selected for this study. Most of the respondents were male (92%) with an overall average age of 51 years and were involved in rearing camels for 15 years. Over 90% of the respondents were married, but only 4% indicated to have had some form of formal education, mainly primary level. Households had between 4 to 12 individuals with land ownership predominantly private where the household was located but communally owned at far-flung in the grazing areas. The total number of camels in a herd ranged from 10 to 287, and these were held together with other livestock species such as cattle, goats and sheep. More than half of the camel calves sampled in this study were male, with an average age and weight of 7 months and 169 Kg, respectively. Over two-thirds of the camel calves had a rough hair coat, while the median body condition score was 2.

Prevalence ofegg/oocyst counts of gastrointestinal parasites

The overall prevalence of gastrointestinal parasites (calf positive for *Strongyloides* spp, Strongyle type, *Nematodirus* spp, Coccidia or *Moniezia* spp) in camel calves was 42% (130/308). About 31% (96/183) of those that were positive for gastrointestinal parasites had nematodes (*Strongyloides* spp, Strongyle type or *Nematodirus* spp), About 14% (44/308) had cestodes of *Monezia* spp while 3.9% (12/308) had coccidia. Out of the 95 samples that had nematodes, 47 (49%) had *Nematodirus* spp, 42(44%) had *Strongyloides* spp, and 38 (40%) Strongyle-type eggs. The highest average number of eggs per gram of faeces (EPG) was seen in

Table 1. Summary of the farmer demographics and farm characteristics for the camel herds in Isiolo County, July-August 2021.

Continuous Variable					
Variable	**Number**	**Mean**	**SD**	**Median**	**Range**
Age of the respondent (years)	25	50.9	12.8	53.0	18.0-72.0
The number of people in the nuclear family	25	8.8	2.9	10.0	4.0-12.0
Number of years involved in camel rearing	25	14.6	8.3	14.0	1.5-30.0
Total number of camels in the herd	25	90.7	80.5	69.0	10.0-287.0
Total number of cattle owned	25	5.0	14.7	0	0-54.0
Total number of goats owned	25	47.3	70.5	0	0-285
Total number of sheep owned	25	25.4	43.6	0	0-148
Total number of donkeys owned	25	1.6	1.7	1	0-7
Distance covered to access pasture (Km)	25	7.3	3.5	7.0	3.0-15.0
Distance covered to access water (Km)	25	4.6	2.5	4.0	2.0-10.0
Total milk yield per day	25	34.7	25.0	20.0	5.0-80.0
Average age of the camel at first calving (Months)	25	56.6	9.5	60	36- 72
Average calving interval of the camel (Months)	25	25.9	6.6	24	24-48
Average weaning age of the camel calves (Months)	25	12.5	2.4	12	12-24
Average number of calves per herd	25	37.6	31.4	31	3-104

Categorical variable			
Variable	**Category**	**Number**	**Proportion (%)**
Gender of the respondent	Male	23	92
	Female	2	8
Highest level of education attained by the respondent	None	24	96
	Primary	1	4
Marital status of the respondent	Married	23	92
	Single	2	8
Position of the respondent in the family	Husband	21	87.5
	Wife	2	8.3
	Child	1	4.2
Land ownership status	Private	15	62.5
	Communal		

Monezia spp. (1352.3±4618.3) and *Strongyloides* spp. (911.9±1692), while the mean number of oocysts per gram of faeces (OPG) for coccidia was lowest at 525±767.7 (Table 3).

Factors associated with gastrointestinal parasites

The following factors were found to have univariable association (p≤0.3) with nematode eggs in faeces: Respondents' level of education, total milk yield per day, age of the calf, body condition score, live body weight and the condition of the hair coat (Table 4).

In the final nematode infection model, three variables, age of the calf, total milk yield per day and calf live weight were found to be significantly associated (p≤0.05) with the presence of nematode eggs (Table 5). A unit increase in the age and the live weight of the camel calf increased the odds of having nematodes by 19 and 1%, respectively. Also, a unit increase in average herd milk yield increased the odds of camel calves having nematodes by 15%.

In the final *Nematodirus* spp. infection model, three variables: age of the calf, calf live weight and average

Table 2. Summary of the farmer demographics and farm characteristics for the camel calves in Isiolo County, July-August 2021.

Continuous Variable					
Variable	**Number**	**Mean**	**SD**	**Median**	**Range**
Age of the calf (months)	308	7.3	3.0	7	1-24
Body condition score	308	2.3	0.5	2	1-4
Live body weight (Kgs)	308	169.0	41.3	167.5	25- 272

Categorical Variable			
Variable	**Category**	**Number**	**Proportion (%)**
Animal number per sub-county area	Isiolo Central	184	59.7
	Garbatulla	124	40.3
Sex of the camel calf	Male	177	57.5
	Female	131	42.5
Hair coat condition	Smooth	92	29.9
	Rough	216	70.1

Table 3. Summary statistics of eggs per gram (EPG) or oocysts per gram (OPG) of parasites identified in camel calves with positive fecal samples in Isiolo, July-August 2021.

Parasite name	(n=308)	Proportion of positive calves	MeanEPG orOPG	SD	Median	Range
*Strongyloides*spp	42[a]	13.6	911.9	1692	200	100-8200
Strongyle type	38[a]	12.3	257.9	220.1	200	100-1000
*Nematodirus*spp	47[a]	15.3	449.1	772.2	200	100-4500
Coccidia	12[a]	3.9	525.0	767.7	300	100-2900
*Moniezia*spp	44[a]	14.3	1352.3	4618.3	200	100-30000

[a]Number of animals that were positive for the parasites.

Table 4. Univariable associations of predictor variables with presence of nematodes EPG≥100 (*Strongyloides* spp. strongly type or *Nematodirus* spp.).

Variable	Type	P-Value
Highest level of education attained by the respondent	Categorical	0.003*
Number of years involved in camel rearing	Continuous	0.362
Total number of camels in the herd	Continuous	0.910
Total milk yield per day	Continuous	0.055*
Age of the calf	Continuous	<0.001*
Body condition score	Continuous	0.248*
Live body weight	Continuous	<0.001*
Animal number per sub-county area	Categorical	0.098*
Sex of the camel calf	Categorical	0.433
Hair coat condition	Categorical	0.016*

*Variable with p values ≤ 0.30.

weaning age of the camel calves were found to be significantly associated (p≤0.05) with the presence of *Nematodirus* spp eggs (Table 5). A unit increase in the age and the live weight of the camel calf increased the odds of having *Nematodirus* spp. eggs by 20 and 2%, respectively. Also, a unit increase in the average weaning age of the camel calves decreased the odds of camel calves having *Nematodirus* spp. eggs by 35%.

Table 5. Final multilevel mixed-effects logistic regression models of presence of nematodes (positive for *Strongyloides*spp, Strongyle type or *Nematodirus*spp eggs) and *Nematodirus*spp eggs in fecal samples of 308 camel calves in Isiolo County, July-August 2021.

Variable	Frequency	OR	CI	p-value
Nematodes				
Total milk yield per day (l)	308	1.02	0.99- 1.04	0.059
Age of the calf (months)	308	1.19	1.06- 1.35	0.005
Live body weight (kg)	308	1.01	1.01- 1.02	0.038
Nematodirus				
Age of the calf (months)	308	1.20	1.04- 1.38	0.014
Live body weight (kg)	308	1.02	1.01- 1.03	0.005
Average weaning age of the camel calves (months)	25	0.74	0.60- 0.92	0.005

The area under the receiver operating characteristic curve for these final models was 0.80 and 0.87 for nematode infection and *Nematodirus* spp. infection respectively, indicating an excellent overall goodness-of-fit–fit of the observed data.

DISCUSSION

In this study, the overall prevalence of gastrointestinal parasitism in camel calves was 42%, which is similar to that reported in Algeria (Bouragba et al., 2020) but lower than the ones noted in Tanzania (Swai et al., 2011); Egypt (El-Khabaz et al., 2019) and Ethiopia (Bekele, 2002; Demelash et al., 2014; Duguma et al., 2014). The prevalence of *Nematodirus* spp. in the current study was higher than that of other nematodes and was similar to what has been reported previously (Tajik et al., 2011; Radfar and Gowhari, 2013) although different from other studies that reported strongly species as the most prevalent nematode (Swai et al., 2011; Duguma et al., 2014; El-Khabaz et al., 2019).

Contrary to other reports, the 3.9% coccidia infection in this study was lower than what has been reported previously in Iran (Radfar and Gowhari, 2013) but higher than the 1.3% reported in southern rangelands of Ethiopia (Duguma et al., 2014).

The faecal floatation method used in this study was likely to underestimate *Moniezia* infection as it is not the most appropriate detection method. Nevertheless, the cestodes were noted and recorded whenever observed in the collected faecal samples. *Moniezia* infection in camel calves, like in most other domestic species, might be of minimal clinical significance even when identified from a faecal sample (Kimeli et al., 2020).

The findings of this study suggest that gastrointestinal parasite infections are important production constraints factors to consider in the camel herd management as high infection could have severe implications on the growth, health and welfare of calves (Radfar and Gowhari, 2013). High endoparasite infections could also hamper productivity in adult camels and consequently affect the livelihood of pastoral communities (Radfar and Gowhari, 2013). Some gastrointestinal parasites are of zoonotic importance (Chhabra and Singla, 2009) and can potentially contaminate camel milk and meat and thus threaten food safety and public health (Zhu et al., 2019). It is also worth noting that apart from *Strongyloides* spp, which are particular nematodes of the camels, all the other gastrointestinal parasites observed in this study are shared with other domestic animals (Ballweber, 2009). Since pastoralists in Isiolo County practice mixed livestock production systems, camels can be crucial in distributing these parasites to other domestic animals due to common grazing pastures. The reverse is also possible because camels can pick gastrointestinal parasites from other livestock species.

This study observed a significant association between higher milk yield in a herd and increased nematode infection in camel calves. This finding were attributed to the fact that in the study population, the amount of milk produced within a herd was influenced more by the number of lactating camels than production per individual animal. As such, more milk meant bigger herd size and consequently heavy contamination of pastures with gastrointestinal helminths, which calves easily picked while grazing with adult camels.

The observed association between higher nematode infections and the age of calves is in agreement with previous studies (Tajik et al., 2011; Demelash et al., 2014; Guowu et al., 2020). Generally, younger calves are confined within the households where they are fed and cared for. However, as they age, the calves are usually weaned and released to graze in pastures with adult camels (Mirkena et al., 2018). Access to grazing fields leads to higher exposure of the calves to helminth eggs and infective larvae that are shed by the adult camels (Hansen and Perry, 1994). This argument was further supported by the finding that delayed weaning of calves was significantly associated with lower *Nematodirus* spp.

infection.

The finding that heavier calves were more prone to nematode infections is likely associated with the fact that such camel calves are grazed in the pastures with adults where there are abundant pastures compared to the household surroundings and are likely to pick infections in the course of grazing (Hansen and Perry, 1994). Generally, the weight of the camel calves tends to increase with age, and as this happens, the calves are usually released to graze as milk alone cannot meet the nutritional demand for growth (Mirkena et al., 2018). The latter leads to calves being exposed to infection as they graze due to contamination of pasture by the adult camel.

CONCLUSIONS AND RECOMMENDATIONS

The burden of the gastrointestinal parasite infection in camel calves raised in Isiolo County, Kenya, was moderate and associated with factors like age, body weight, herd milk yield and age at weaning. The study, therefore, recommends stringent gastrointestinal parasite management through targeted deworming, preferably 2 to 3 weeks after the calves are introduced to grazing in pasture with the adult camels and at the start of the rainy season.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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