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Situation of ticks and seroprevalence of *Theileria parva* in two farming systems in Nakaseke and Nakasongola districts of Uganda

Kwesiga S.[1, *], Okello-Onen J.[1, 2], Ogwal Byenek S.[1], Otim-Nape W.[1]

[1] Africa Innovations Institute, Kampala-Uganda. [2] Department of Biology, Gulu University.
*Corresponding author. kwesigastephen@yahoo.com

Abstract. This study delved into the composition of ticks, prevalence of *Theileria parva* and management of East Coast Fever in Nakaseke and Nakasongola districts of Uganda. The tick challenge on animals was assessed and whole blood was collected for determination of seroprevalence of *Theileria parva* using Enzyme-Linked Immunosorbent Assay. Majority (82.3 percent) of the cattle were found to be infested with *Rhipicephalus appendiculatus* (88.2 percent), *Ambryomma variegatum* (7.5 percent) and *Rhipicephalus evertsi* (4.3 percent). Majority (80.7 percent) of the respondents believed that tick infestation was severe and regularly managed using acaricides (65.3 percent). In the pastoral farming system, no ticks were found on calves below 6 months of age. In the mixed crop-livestock farming system, all cattle age groups were exposed to the ticks. The seroprevalence of *T. parva* varied among age groups of cattle in both farming systems. There was moderate correlation between the mean number of *R. appendiculatus* ticks and seroprevalence of *T. parva* (r = 0.47). Association was established between mean number of ticks and farming system (p = 0.019) and percentage positivity of *T. parva* and farming system (p = 0.007). *Theileria parva* was prevalent in the two farming systems despite frequent application of acaricides. Thus, the study provides evidence of the tick-borne disease pathogens and vectors responsible for ECF, *R. appendiculatus* being the principal tick species infesting cattle in the area. Creation of community-based technical and advisory services for livestock health management is recommended.

Keywords: Epidemiology, Livestock, Rangeland, Tick-borne diseases, Endemic stability.

Introduction

In Uganda, animal husbandry is considered a source of employment and livelihood, representing 47.5% of the gross domestic product (NAPA, 2007; NEPAD-CAADP, 2004). Most of the livestock production in the country takes place in the cattle corridor of the country. However, the productivity of livestock is constrained by ticks and tick-borne diseases (TTBDs) (AfrII, 2010; AfrII, 2011; Okello-Onen, 1995; Mukhebi *et al.*, 1992; Ocaido *et al.,* 1996; Otim, 2000). TTBDs are a major health impediment to the improvement and development of the livestock industry due to the losses they impose on farmers and the economy (Okello-Onen *et al.*, 2002). Ticks cause tick worry, blood loss, damage to hides and skins, tick paralysis, and reduced weight (Bell-Sakyil *et al., 2004;* Okello-Onen *et al.*, 1999). From time immemorial, Tick-borne diseases (TBDs) have caused serious debility, morbidity, mortality and production losses in susceptible *Bos taurine* cattle, their crosses (Bostaurus Linnaeus, 1758) and the indigenous zebu breeds (*Bos indicus*, Linnaeus, 1758) raised in non- endemic areas (Okello-Onen, 1995; Walker *et al.,* 2003). Mukhebi *et al* (1992) and Okello-Onen *et al* (2004) noted that TBDs cause an estimated total direct cost of $ 168m annually and estimated mortality of 1.1M cattle. Tick-borne diseases also hinder the introduction of exotic, more productive stock (Okello-Onen *et al.,* 1994).

Theileria parva, which causes East Cost Fever (ECF), is the most pathogenic among theileria species affecting cattle (Morel, 1989) and is transmitted by the brown ear tick, *R. appendiculatus*. ECF is the most important widespread TBD in Uganda (Kabi *et al*., 2008; Kabi *et al*., 2014 and Okello-Onen, 1995). The diverse distribution and prevalence of ECF are strongly related to its vector dynamics and entomological inoculation rate, host susceptibility, animal breed and age, livestock production system, and the tick control practices Kivaria, 2007; Marufu *et al*., 2010; Rubaire-Akiiki *et al*., 2006). ECF is caused by obligate intracellular protozoa parasites, *T. parva* that infect the host's lymphoblasts. Theileria sporozoites are transmitted to animals through the saliva of the feeding tick and the incubation period for the disease is 8 - 12 days. Matovelo *et al.* (2002) reported that the pathology of the disease, among others, includes fever, enlarged lymph nodes, raised hair, anorexia, laboured breathing, corneal opacity, nasal discharge, diarrhea and anaemia.

In all affected areas, ECF has considerable epidemiological and economic significance. The animals that recover from TBD infections may suffer from, among others; weight loss, low milk yields, low draught power, reduced fertility and delayed maturity (Latif and, Pegram, 1992). In the case of ECF the affected cattle remain carriers and may serve to disseminate the infection (Latif and Walker, 2004; Mugabi *et al*., 2009; Mugabi *et al*., 2010). Tick control management practices largely depend on the use of conventional acaricides such as synthetic pyrethroids, amidines (amitraz), and co-formulated organophosphates and pyrethroids (Latif and Walker, 2004; Thrusfield, 1997; Vudriko *et al.,* 2016; 2018a). Other methods used by farmers include bush burning during dry seasons and, to a less extent, use of botanicals to treat infected animals in typical livestock farming systems. It also includes the use of breeds of cattle that are genetically resistant to tick infestations (Norval *et al.,* 1991; Okello-Onen *et al*., 2002).

Against this background, this study was conducted to provide up to date knowledge and information that decision-makers need to manage TTBDs. It was key in; validating local perspectives and establishing knowledge gaps in the assessment of the current status of ticks and prevalence of ECF. In turn, this would inform livestock development decisions and policies.

Materials and Methods

Study area

The study was conducted in Nakaseke and Nakasongola districts (Figure. 1). The cattle corridor is a rangeland area that spans from North Eastern to the South Western region of Uganda, covering 43% of Uganda's total land area. Up to 65.5% of livestock production in the country takes place here (World Bank, 2011). The two districts are predominantly constituted by pastoral and crop-livestock farming systems. Livestock production is the lifeblood of this area. Indigenous breeds of cattle are the most abundant livestock. Ticks and tick-borne diseases have been reported to be major livestock production obstacle in the area (AfrII, 2011; IPCC, 2007).

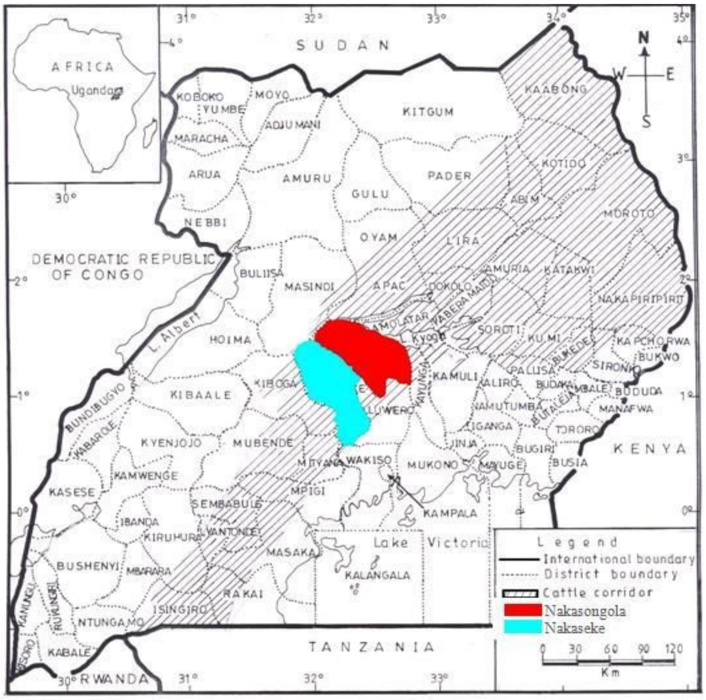

Figure 1. Location of Nakaseke and Nakasongola Districts

Sampling of Household Respondents and cattle population

Communities were stratified into pastoral-majority areas and areas of mixed crop-livestock producers. In each of the two strata, 10 villages, representing 25% of the total number of villages, were randomly selected, using registers at the parish local council chairpersons' offices as the sampling frame. In each of the two districts, 20 villages were selected for the study, and in each of the villages, 10 households were chosen for the study. Making a subtotal of 200 households per district and a grand total of 400 households in the two districts. Computer-generated random numbers were used to select household respondents. Only respondents who were above 18 years of age and preferably household heads were selected for the study after giving their consent.

On an assumption of the prevalence of infection of ECF in cattle being 10%, taking an absolute precision of 5% at the 95% level of confidence, 10% of farms were randomly selected in each village. Using standard epidemiological procedures, the cattle sample size was determined by using a formula given by Thrusfield (1997) giving a total of 384 local breeds of cattle (*Bos indicus*) for this study. On each farm, an average of 3-5 calves ranging between 1-9 months old were sampled.

Data Collection and Management

The instrument used for quantitative data collection was a standard structured closed-ended questionnaire. The pretested and validated tool was administered to the respondents in both pastoral and mixed crop-livestock farming systems by trained research assistants in each district who were familiar with the community and language to capture data of high quality. The questionnaire inquired about tick challenge on cattle, various causes which were believed to result in ECF, distribution, and symptoms of ECF (such as fever/high temperature, nasal discharge, diarrhea, coughing, enlarged lymph nodes, loss of appetite, raised hair) seasonal fluctuations in the occurrence of ECF, sources of information required for treatment of ECF, and on-farm control and management practices of TTBDs.

Data was validated by checking the filled questionnaires to ensure that they were filled correctly. Selected households were geo-referenced using a Global Positioning System (GPS) handset.

The tick challenge and spectrum of tick species were assessed *in situ* by counting and recording the number of adult ticks on one side of each calf examined along the antero-posterior axis (Soulsby, 1982, Walker, 2003). Because ticks are seldom randomly distributed on the animal body but rather confined to a few selected predilection sites, a total tick count was made on one side of the body of each calf at predilection sites instead of making counts per square meter. This number was later doubled to provide the total tick count per animal (Morel, 1989; Thrusfield, 1997). Tick samples were collected from calves by handpicking using steel forceps with blunt ends and serrated inner surfaces (Walker *et al.,* 2003). The tick samples from animals were stored separately in universal tubes containing 70% ethanol as a preservative. The tubes were labeled using pencils with field data which included the date of sampling, collection site, calf predilection site, collector's name, calf age among others using lead pencil writing on paper which was placed inside the tube with the ticks. In the laboratory, ticks were identified to species level using external morphological features namely size of scutum, genital aperture and conscutum among others described by Walker *et al.* (2003). On-farm quantitative serological surveys were conducted to determine the seroprevalence of *T. parva* pathogens and the abundance and diversity of ticks infesting cattle in the study area. The prevalence of *T. parva* in livestock was assessed by collecting whole blood samples from each calf in Ethylene Diamine Tetra Acetic Acid (EDTA) tubes following jugular venipuncture. In the laboratory, the blood samples were centrifuged to obtain sera. Infection with *T. Parva* was determined specifically using an indirect Enzyme-Linked Immunosorbent Assay (indirect ELISA) approach and expressed as percentage positivity (pp) taking 20% as a cut-off point value, as described by Katende *et al.* (1998).

Analysis

Data collected were coded and entered into Epidata version 3.1, coded, cleaned, edited, and exported to MS Excel and Stata version 14 for analysis. Values of $p < 0.05$ were considered statistically significant for associations between farming system and percentage positivity of *T. parva* as well as mean number of ticks per animal and farming system. Summary of statistics in the form of tables and figures were computed. Data from serological tests and tick counts were entered into the Microsoft Excel spreadsheet, 2010. Seroprevalence was determined by expressing positive sera as a percentage of the total number of sera tested.

Results

Household-level perceptions of ticks, ECF, and management of TTBDs

Respondents in both pastoral and mixed crop-livestock farming systems perceived the occurrence of ticks on cattle mainly as a severe challenge 316/400 (79%), followed by moderate

68/400 (17%), mild 12/400 (3%), and the smallest proportion of the respondents 4 (1%) considered it as other challenges. Other than the ones stated above

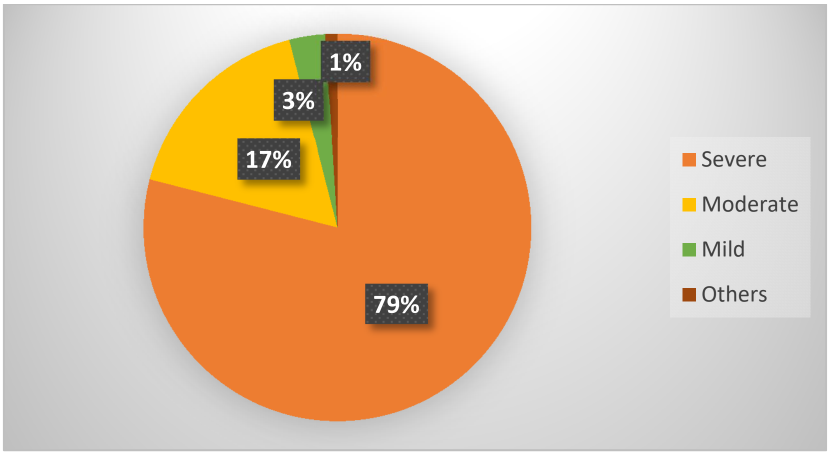

Figure 2. Tick infestation in cattle

By perception, ECF was reported as a prevalent livestock disease in both districts at the household level (Figure 3).

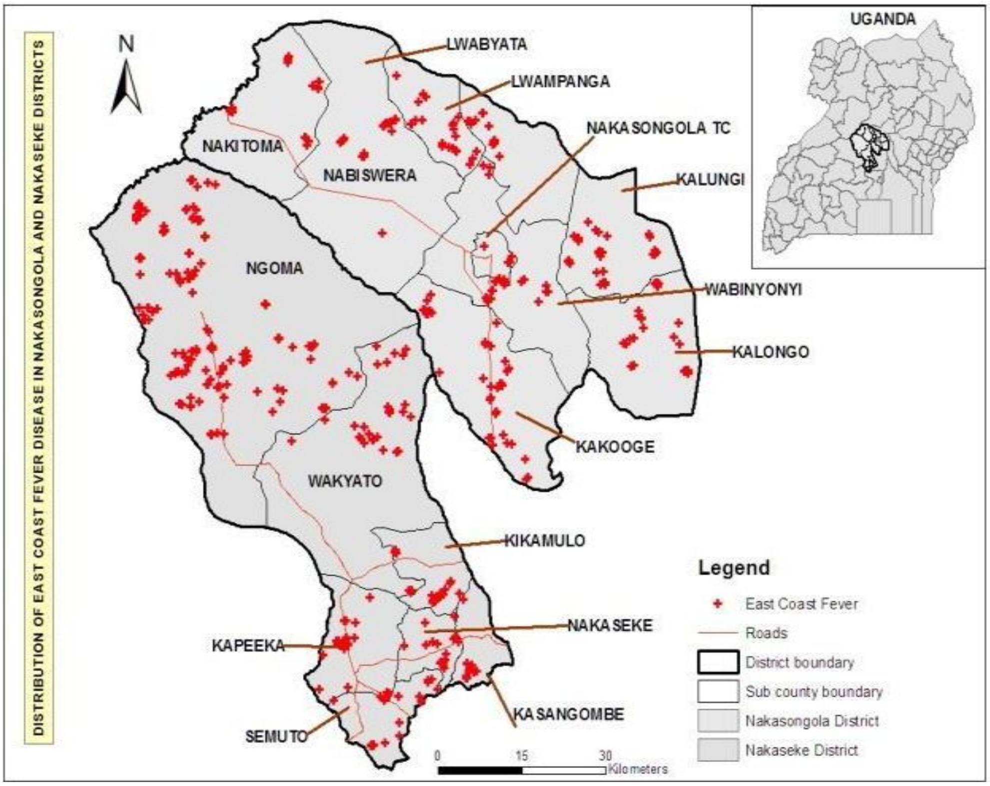

Figure 3. Perceived prevalence of East Coast Fever

Causes perceived by the respondents to result in ECF

About 127/400 (thirty-two percent (31.8%), of respondents wrongly perceived the cause of ECF as being bites by flies, such as tsetse flies (Table 1). This was followed by 79/4000 (19.7%), that perceived ticks as a cause for ECF. ECF was also thought to spread when animals are brought in contact with other animals by about 48/400 (12.1%) of the population. Inadequate pastures in the districts, hence poor feeding of the animals, was perceived by 36/400 (9.1%) of respondents as favouring the occurrence of the disease. A small and insignificant percentage 16/400 (4%) of the respondents thought that the disease in animals could be due to dirty water and prolonged drought.

Table 1. Perceived causes of ECF

Cause	Frequency	%
Lack of pasture/ poor feeding	6	9.1
Dirty water	4	6.1
Ticks	13	19.7
Flies like Tsetse flies	21	31.8
High temperature	3	4.5
Contact with other animals	8	12.1
Dust	3	4.5
Prolonged drought	4	6.1
Other reasons	4	6.1
Total	66	100

Community perspectives on the percentage distribution of ECF symptoms

Both communities enlisted a diverse range of symptoms believed to manifest ECF, and about 20% and 21% of respondents perceived and ranked fever or high temperature and enlarged lymph nodes, respectively, as the most important symptoms. These were followed by raised hair coat (16.0%) and loss of appetite (13.5%) (Table 2).

Table 2. Perceived distribution of symptoms of East Coast Fever

Symptoms of East Coast Fever	Frequency	%
Fever/High temperature	108	19.6
Nasal discharge	34	6.2
Diarrhea	46	8.4
Coughing	36	6.5
Enlarged lymph nodes	115	20.9
Loss of appetite	74	13.5
Loss of appetite/Emaciation	24	4.4
Raised hair	88	16.0
Lameness	10	1.8
Others	15	2.7
Total	550	100

Source of ECF treatment information

About 34.9% of the respondents reported having got information on ECF treatment from veterinary doctors, 25.6% of them were advised by relatives, while 23.3% obtained advice from fellow farmers. The least providers of such information were local political leaders at various levels of local councils (10.5%) and government (5.7%) (Table 3).

Table 3. Source of information on the East Coast Fever treatment

Perceived source of treatment information	Frequency	%
Government	4	4.7
Veterinary doctors	30	34.9
Local leaders (such as local council 1,2 or 3)	9	10.5
Fellow farmers	20	23.3
Relatives	22	25.6
Others	1	1.2
Total	**86**	**100**

Seasonal occurrence of TTBDs

About 58% of the respondents reported that ECF was a common disease in both the rainy and dry seasons (Figure 4). Nonetheless, relatively few respondents believed that this disease was a problem, neither in rainy (20.8%) nor in dry seasons (21.2%).

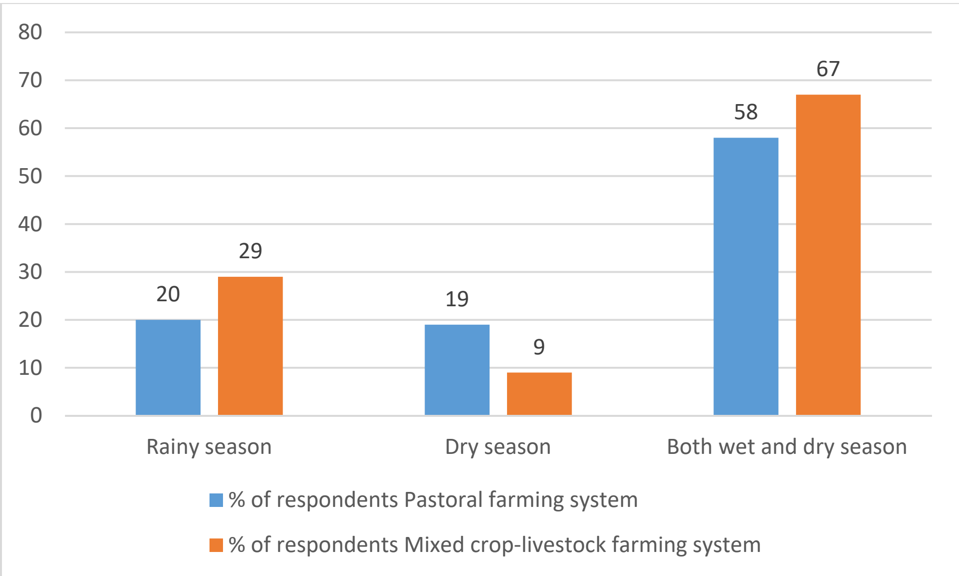

Figure 4. Occurrence of ticks in different seasons

Management of TTBDs

The largest percentage (65.3%) of cattle keepers bought synthetic acaricides to treat their cattle (Table 4). This was followed by 17.2% who used private veterinary doctors, (10.4%) that used government veterinary officers and a small proportion (5.6%) of them used local herbs such as *Erythrina abyssinica (Ejirikiti)*. Tick control was done mainly by spraying acaricides with less technical guidance but rather done on personal perception.

Table 4. Management practices for ticks and tick- borne diseases control

Practice	Frequency	%
Use local herbs for treatment	64	5.6
Use synthetic chemicals/acaricides	752	65.3
Call government veterinary officers	120	10.4
Use private veterinary officers	198	17.2
Just look on (no option to do)	6	0.5
Others	11	1.0
Total	1151	100

On-farm assessment of ticks and seroprevalence of *T. parva* in cattle

Species diversity and the total number of ticks identified

From a sample of 384 calves examined, 316/384 (82.3%) were found to be infested with ticks of different species. A total of 3,283 Ixodid ticks belonging to different species were collected. Out of these, 2895/3283 (88.2%) were of the species *R. appendiculatus* and found on the cattle's ears (Figure 5). These were followed by those of *Ambryomma variegatum* species (247/3,283, 7.5%) which were on the dewlap, axillae, udder, and groin. The rest 141/3,283 (4.3%) of the ticks were *R. evertsi evertsi* species, which were picked around the anus. Therefore, the study yielded three types of ticks of economic importance in the livestock hotspot production area in Uganda and these were *R. appendiculatus, A. variagatum and R. evertsi*. Of these, *R. appendiculatus,* also called the brown ear ticks, the vector for *T. parva* haemoparasite which cause ECF was the most prevalent tick species.

This resonates well with the observed high seroprevalence of *T. parva* in serum samples collected. This was proved statistically by a moderately positive correlation coefficient (r) that existed between the mean number of ticks per animal and percentage positivity (pp) of *T. parva.*

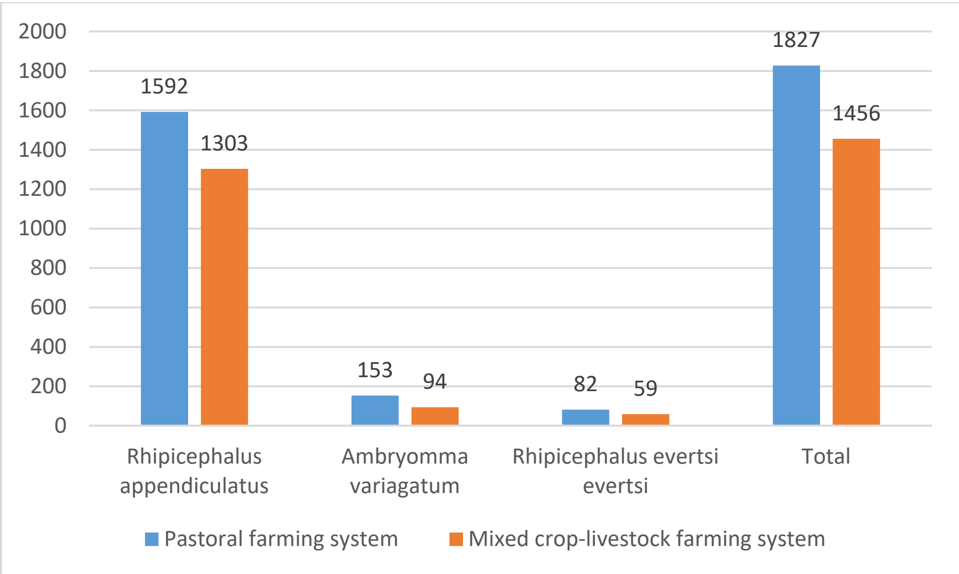

Figure 5. Types of ticks found on cattle

There was a positive correlation (r = 0.47) between mean number of ticks per animal and the seroprevalence of *T. parva.* A rise in mean tick number per animal translated into increased seroprevalence of *T. parva.* The farming system was significantly associated (p=0.007) with the proportion of *T. parva*, (Table 5), and the mean number of ticks per animal, p = 0.008.

Table 5. Farming system, % positivity of *T. Parva and* Mean number of ticks per animal

	Source	SS	df	MS	F	Prob > F
Farming system and % positivity of *T. parva*	between groups	4160.25	1	4160.25	8.18	0.0072
	within groups	17282.5	34	508.309		
	Total	21442.8	35	612.65		
Ticks per animal and Farming system	between groups	478.463	1	478.463	11.78	0.0018
	within groups	1177.73	29	40.6114		
	Total	1656.19	30	55.2065		

Seroprevalence of T. parva in the different farming systems

In the pastoral farming system, the number of *R. appendiculatus* ticks per animal ranged between 0 and 15. No ticks were found on calves aged less than 6 months. Comparatively, the serological tests showed that the prevalence of *T. parva* was below the cut-off point of 20% within the age groups of calves below 4 months of age. However, after 5 months, the prevalence shot up to 65% and drastically dropped at the age of 6 months to the below cut-off point of 20% and this was maintained for up to the age of 9 months (Figure 6). In the pastoral farming system, the mean tick number per animal also varied greatly with age group of calves ranging from zero to 15. The prevalence decreased steadily from newly born calves, up to three months old calves. It was observed that the prevalence increased steadily reaching a peak in calves that were 6 months old, with fluctuations noticed among age groups of up to 9 months (Figure 6).

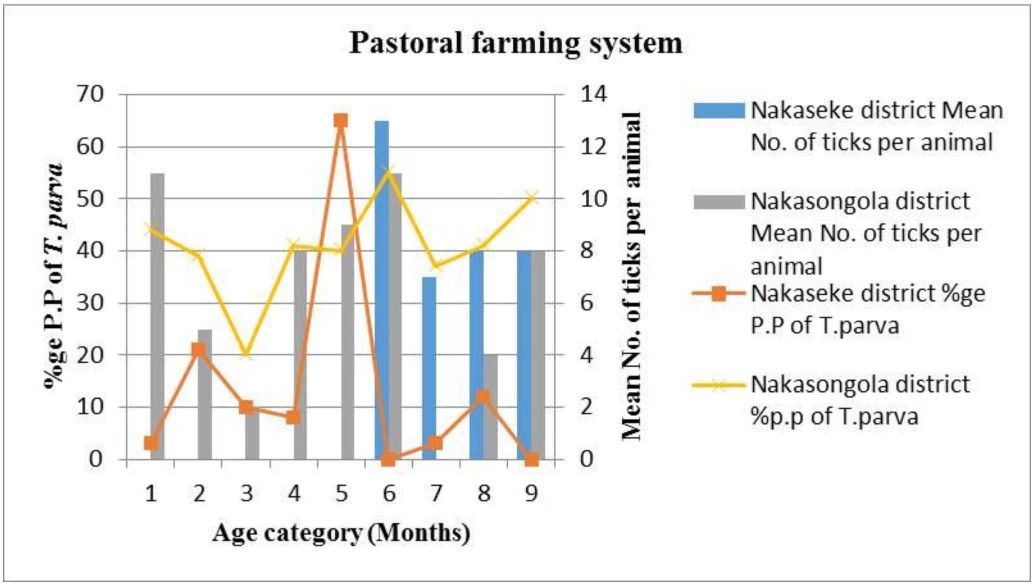

Figure 6. Variations of mean number of ticks per animal pp of T. parva with age of calf in the pastoral farming system

In the mixed crop-livestock farming system, the mean number of ticks per animal varied greatly, ranging from 2 to 24. In the system, all the age groups of calves were exposed to the tick challenge. The prevalence increased from 1-month-old calves and reached a peak in calves of 2-3 months old. Comparatively, a drastic dropped was observed in calves 4 months old. Contrastingly still, the seroprevalence gradually increased reaching a peak of 70% among calves aged 7 months (Figure 7). In the mixed crop-livestock farming system, the mean number of ticks per animal ranged from 14 to 28, with no ticks seen on calves up to 1 month of age. The prevalence of *T. parva* sharply decreased from newly born calves to calves aged two months, reaching a level of 30%. It gradually increased across age groups, with a peak of 63% observed among calves of 6 months of age, (Figure 7).

Generally, there was paucity or no established infrastructure for effective management of ticks and TBD for sustainable livestock production.

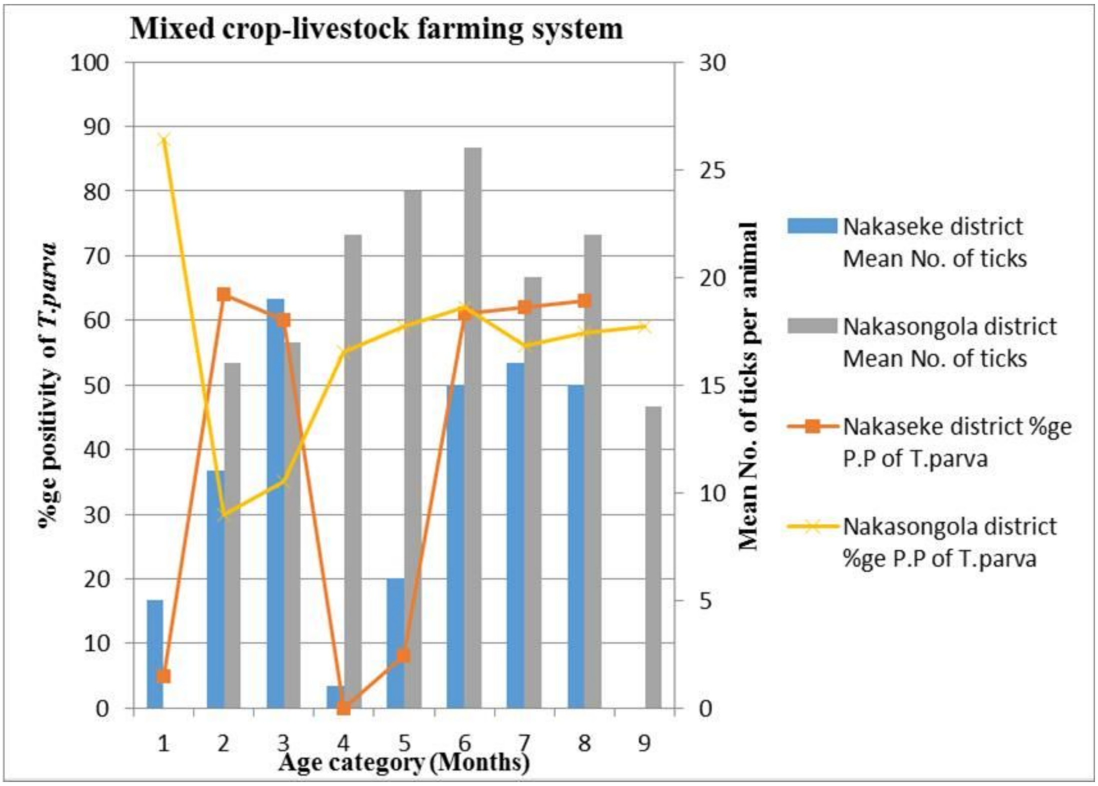

Figure 7. Variations of mean number of ticks and pp of *T. parva* with age of calf in the mixed crop-livestock farming system

Discussion

Quantitative data collection using questionnaires provided useful insights regarding farmers' perspective on the status quo and prevalence of ticks and ECF and how these were routinely managed in the two farming systems. The findings of this study highlight existing tick infestation challenges and prevalence of *T. parva* among local breeds of cattle in the study area.

These findings provide baseline data on the status of ticks and ECF pathogens that can inform the development of sustainable and effective livestock health management strategies. This will serve to guide future epidemiological studies even though cross-sectional studies tend to be limiting at determining a cause-effect relationship. Most of the respondents in both farming systems lucidly identified the challenge of cattle tick infestation as being severe and mentioned theileriosis as a prevalent TBD in the two districts. The prevalence of *T. parva* was observed to be a mirror image of the tick population. This was in conformity with results from on-farm tick collections and serum samples from calves which revealed diversity and infestation of ticks on cattle expressed as mean tick number per animal and high pp of *T. parva* respectively in both farming systems in the two districts. The prevalence of *T. parva* is a mirror image on the tick challenge. The disease was reported to be prevalent in dry and wet seasons (58% and 67% in the pastoral and mixed crop-livestock farming systems respectively). This observation is supported by Latif and Walker (2004) findings on the seasonality of ECF.

The authors assert that the activity of many species of ticks is adapted to seasonal variations and in the tropics, this is usually to overcome the adverse effects of a long dry season. The survival of a number of species of ticks is improved in situations where seasonal cycles exist. This reduces these risks, for example, *R. appendiculatus* has mechanisms, known as diapause, that delay the questing of adults so that their feeding and reproduction starts at the beginning of the single rainy season (Latif and Walker, 2004; Mugabi *et al.*, 2009). This is followed by peak numbers of larvae toward the end of the rainy season when humidity is highest. Considering farmers' perceptions of various causes believed to result in ECF, a relatively small fraction (19. 7%) of respondents could identify the cause of ECF as ticks. The largest proportion of respondents (31.8%) wrongly identified the cause of the disease as being flies such as tsetse flies and the rest gave other causes which could be the cause of the disease.

Therefore, the largest percentage of respondents (80.3%) did not have outstanding knowledge and information regarding the cause of ECF. The cause of t*rypanosomiasis* was most perceived to be the cause of ECF. Regular control and management of TTBDs largely depended on the use of synthetic acaricides (65.3%). The findings of this study emphasize what Latif and Walker (2004) noted that the threat of serious exposure of cattle herds to ECF has led to substantial use of tick control systems, mostly relying on acaricides. Among the available sources of information on the treatment of ECF listed, the government was mentioned among the worst performers as far as providing access to such information was concerned. Therefore, it implies that there was a paucity of the government's infrastructure on the management of TTBDs. This highlights a weakness, risk, and gap in enhancing livestock production and development, especially in the cattle corridor where most of the livestock production in the country takes place. The observed tick infestation among cattle in the study areas could be attributed to communal grazing practice that exposes animals to tick-infested areas. This may increase the risk of occurrence to tick-borne pathogens.

These findings were consistent with earlier studies conducted in the country that reported ECF as the most economically important TBD of cattle which is endemic in Uganda (Kabi *et al.,* 2014; Muhanguzi *et al.,* 2014; Ocaido *et al.*, 2009; Rubaire-Akiiki *et al.,* 2006; Vudriko *et al.* Generally, results indicated that calves of all age groups were exposed to the tick challenge which translated into infection with *T. parva* (r=0.47). This was further evidenced by the fact that most of the values were above the cut-off titer value of 20% pp indicative of high infection rates with *T. parva* in the local breeds of cattle. Results indicated that calves of all age groups where exposed to tick infestation challenge at an early stage in life in the mixed crop-livestock farming system. The fact that the tick challenge was evident in the study area with minimal reported calf mortality indicates that in this endemic region for ECF cattle have already been naturally selected for tick resistance as reported by Moll *et al* (1986) and Young (1981). Part of this selection may be due to challenge with *T. parva* since cattle with resistance to ticks will have a lower *T. parva* challenge and survive (Moll *et al.,* 1986, Young *et al.,* 1988; Young 1981).

The point of concern to the livestock farmers, in this case, is to ensure that there is a judicious application of the acaricides. If acaricides are used intensively, livestock will not be exposed to disease pathogens and as a result, fail to acquire natural immunity. When this occurs, the livestock have increased susceptibility to disease and a situation of endemic instability arises: disease outbreaks are likely if acaridae use is not maintained. It is often best to achieve a state of endemic stability where there is sufficient exposure to ticks and transmitted pathogens to give high levels of naturally acquired immunity in the population of livestock (Okello-Onen *et al.,* 1994). Some animals will be lost to tick-borne disease but the cost may be less than the cost of intensive treatment. Besides, the application must be done in such a way as to reduce the rate at which ticks become resistant to the acaricides. This requires regular monitoring and surveillance of vector-parasite dynamics. Although most of them controlled tick numbers on animals through the use of acaricides as reported, the number of ticks count per animal was high. This was so even in instances where farmers had indicated that they had applied acaricides on the animals a few days before conducting on-farm surveys.

Therefore, there is a need to investigate the brands of acaricides used, the frequency of their application, dosage applied, the way the drugs are applied on the animals (Young *et al.,* 1988), to assess local acaridae resistance status. In the pastoral farming system, no ticks were found on calves aged less than 6 months. These findings concur with what Vudriko *et al* (2016) discovered, arguing that many farmers restrict calf exposure to tick challenge by keeping them indoors up to the age of six months. Seemingly good as it may be to these farmers, unfortunately, it gives rise to a population of disease naïve adult animals in which rates of infection and disease susceptibility increase with age. Therefore, exposure to tick challenge at all ages of cattle must be allowed to create a state of endemic stability as it was in the case of crop-livestock farming system.

Conclusions

The study findings provide evidence of the important tick-borne disease and vectors responsible for ECF, *R. appendiculatus* being the principal tick species infesting cattle in the study areas. One of the limitations of this study is that sampling was carried out in the dry season and this may have influenced tick population dynamics. Also, only one disease pathogen, *T. parva* was tested for in the serum samples as this is what could fit within the available resources. strategic tick control during peak periods is necessary to allow ticks to naturally sustain endemic stability of TBDs through a continuous challenge. The abundance of the observed tick species may suggest that humans in the sampled sites are exposed to the risk of diseases when bitten by infected ticks. Therefore, surveillance of TBDs in humans in the study areas is also recommended. There was considerable risk to ECF in the cattle herds within the two farming systems posing a threat to livestock development and improvement of livelihoods of local communities whose lifeblood is livestock farming. Failure to know correct symptoms for ECF by respondents necessitates sensitization of local communities about the actual symptoms of the disease. This is so because correct clinical diagnosis of disease symptoms and treatment would help the poor and resource-constrained farmers not to waste their finances while buying wrong drugs as the wrong diagnosis leads to the wrong treatment. In addition, this could result into fatal consequences on their livestock.

Recommendations

There is an urgent need to create community-based technical and advisory services for livestock health management. This could be achieved by thorough training of extension service providers, who are capable of conveying the necessary technical information and guidance to cattle farmers on the best bet management practices for TTBDs.

One of the promising options for control of TTBDs in this area is breeding for tick resistance for subsequent development of herd immunity. This will become even more useful with the introduction of different breeds of cattle in the area for increased milk and meat production. Under such conditions, tick management can be enhanced through the establishment of a robust breeding program for example cattle breeds indigenous to Uganda typically Short East African Zebu and Ankole Longhorn cattle have a good heritable ability to acquire natural resistance to the feeding of ticks (Latif and Walker, 2004; Okello-Onen *et al.,* 2002). This characteristic can be used in these breeding programs to produce crosses with more productive exotic cattle of the *Bos taurus* type which can give good resistance to ticks and good production. When tick nymphs feed on resistant calves, these normally turn only half normal weight. Consequently, they molt into small adults with reduced survival and reproductive potential, thus reducing the numbers of the tick population in general (Norval *et al.,* 1991).

Further epidemiological studies are required to determine seasonal patterns in diversity, distribution, and abundance. Also, there is a need to assess the prevalence and economic impact of other tick-borne haemoparasites.

Rather than controlling tick population by intensive and extensive application of acaricides without proper application procedures and formulations which encourage selection of resistant tick populations, there must be a deliberate move to adopt integrated tick control measures in the area.

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