Farmers' perceptions on technical controls and risk factors of East Coast Fever caused by *Theileria parva* in Mountainous Kivu, Democratic Republic of Congo

Fabrice Kwankanaba Bantuzeko [1*], Arsene Ciza Mushagalusa[1, 2], Chance Aksanti Barume[1, 3], Yannick Mugumaarhahama[1, 2] and Amzati Gaston Sefu [2, 4].

[1] Research Unit of productions and Animal Heath, Faculty of Agricultural and Environmental Sciences, Université Evangélique en Afrique P.O. Box 3323, Bukavu, Democratic Republic of the Congo

[2] Research Unit of veterinary Epidemiology and Biostatistics, Faculty of Agricultural and Environmental Sciences, Université Evangélique en Afrique P.O. Box 3323, Bukavu, Democratic Republic of the Congo

[3]Research Unity in Environmental and Evolutionary Biology, Department of Biology, Faculty of Sciences, Institute of Life-Earth-Environment (ILEE), University of Namur (UNamur), Rue de Bruxelles 61, 5000 Namur, Belguim.

[4] Unit of Integrated Veterinary Research, Department of veterinary Medicine, Faculty of Sciences, Namur Research Institute for Life Sciences (NARILIS), University of Namur (UNamur), Rue de Bruxelles 61, 5000 Namur, Belguim .

Author of correspondence: fabricebantuzeko@gmail.com

Keywords: Epidemiological investigation, Tick diseases, Control strategies, South Kivu.
Mots clés : Enquête épidémiologique, Maladies à tiques, Stratégies de contrôle, Sud-Kivu

Submission 5/11/2021, Publication date 28/02/2022, http://m.elewa.org/Journals/about-japs/

1 ABSTRACT

The goal of this study on farmers' perceptions of East Coast Fever (ECF) control techniques and risk factors was to contribute to the improvement of tick disease control systems by evaluating the various types of control used, determining the epidemiological status, and identifying risk factors for ECF. ECF was found to be the most common tick-borne disease in a survey of 292 farmers in South Kivu province, particularly in the mountainous region of Kivu (95.9 %). The farmers' most common symptom of ECF was inflammation of the parotid glands, a prominent clinical hallmark of tick-borne illnesses (β=2.22±0.48). The most frequent technique of ECF control (90.4%), with an estimated cost of $2.1 per cow per year, is the use of an acaricide. Although deltametrin is the most extensively used acaricide (P<0.001), coumaphos is the most generally available and effective acaricide. *Tetradenia riparia* is the most regularly used medicinal plant acaricide (P=0.001 and β=2.65±1.05), with *Nicotiana tabacum* being the most effective and widely utilized. The most commonly utilized medicine for therapy was oxytetracycline (P<0,001), although buparvaquone (75 %) was recognized as the most available and effective drug. A highly significant difference (P<0.001) exists between young cows and calves in comparison to adults, indicating that calves (β=1.16±0.25) documented more illness cases than young cows. When compared to young cows and calves, mature animals did not have a substantially higher mortality risk or lethality rate (P=0.632). In terms of epidemiology, the disease is endemic, with this state impacted by various 'groupements,' especially in Miti and Mudaka, cow breeds (Friesland (P=0.006), Sahiwal (P=0.001), and Ankoles (P=0.014)), pasture area (P=0.02), and veterinary assistance (P=0.013). To ensure the safety of livestock and to facilitate the development of new acaricidal and theilericidal products, specific studies to confirm the efficacy of plants used in the control of ticks, particularly *Rhipicephalus appendiculatus*, and the control of the parasite (*Theileria parva*) should be carried out by trials.

RESUME
Cette étude sur les perceptions des éleveurs sur les techniques de contrôle et les facteurs de risque de l'*East Coast Fever* (ECF) s'est réalisée dans le but d'évaluer des différents types de contrôle appliqués contre les maladies à tiques, la détermination de l'état épidémiologique et l'identification des facteurs de risque de l'ECF. Pour cet effet, une enquête épidémiologique réalisée auprès de 292 fermiers de la province du Sud dans les régions du Kivu montagneux a prouvé une occurrence de l'ECF dans les fermes (95,9%). L'inflammation des ganglions parotidiens représente le symptôme commun pour la présence de l'ECF (β=2.22±0.48). Quant aux stratégies de contrôle des maladies, la plus utilisée est la lutte acaricide (90,4%) avec un cout estimé 2,1$ par bovin par an. La deltamètrine est la plus utilisée (P <0,001) et la cypermethrine, la coumaphos les plus disponibles et efficaces. La *Tetradenia riparia* est la plus utilisée parmi les plantes acaricides (P=0,001 et β 2,65±1,05) et la *Nicotiana tabacum* la plus efficace et la plus utilisée pour les plantes contre le parasite. Pour le traitement contre le parasite, l'oxytetracycline a la probabilité d'être plus utilisée (P<0,001) et la buparvaquone la plus efficace parmi les médicaments. Une différence hautement significative est observée(P<0,001) entre les jeunes et veaux en référence aux adultes et indique que les veaux (β : 1,16±0,25) ont enregistré plus de cas de maladies que les jeunes. Les animaux adultes n'ont pas présenté de risque de mortalité et le taux de létalité significativement différents (P=0,632) par rapport aux jeunes vaches et veaux. L'état épidémiologique démontre qu'elle est une maladie endémique dans le milieu d'étude et est influencée par les différents groupements (P < 0.001) notamment les groupements de Miti et de Mudaka, les différentes races notamment Friesland (P=0.006), Sahiwal (P=0.001) et Ankoles (P=0.014), la superficie du pâturage (P =0,020) et l'assistance vétérinaire (P=0,013). Cependant, les études spécifiques pour confirmer l'efficacité des plantes utilisées lors du contrôle des tiques spécialement la *R. appendiculatus* et le contrôle du parasite (*T. parva*) devraient être faites par des essais afin d'assurer la sécurité du cheptel et faciliter le développement de nouveaux produits acaricides et theiléricides.

2 INTRODUCTION

Tick-borne infections are a serious impediment to the growth of cattle breeding in most Sub-Saharan African countries (Mwendia *et al.,* 2014). Among these diseases, Bovine theileriosis also called East Coast Fever (ECF) caused by *Theileria parva* and transmitted by the tick *Rhipicephalus appendiculatus* (Gachohi, 2009; Nene *et al.,* 2016) is among the most common. Due to the exceedingly huge financial losses, this illness is considered the most important protozoan disease of livestock (Bazarusanga, 2008; Mtambo, 2008; Muhanguzi *et al.,* 2014). These losses are linked to significant animal mortality and/or productivity decreases, as well as annual cattle sales to cover the expensive treatment costs (Farougou *et al.,* 2007; Marcellino *et al.,* 2011). In most rural areas, the ECF possesses a major challenge and is attributed to the low number of clinical veterinarians in those areas making it difficult to detect the pathogens at the local level (Hakwale *et al.,* 2003; Kalume *et al.,* 2012). This hinders the development of cattle breeding due to the production losses that can be prolonged even after the animals have recovered, especially in most rural areas in mountainous Kivu's (Kalume, 2012). Despite advances in the veterinary sector, which have resulted in the deployment of ECF control systems involving tick management, host immunization, chemotherapy, and a combination of techniques (Gachohi *et al.,* 2012). These methods, particularly host immunization and pest control with acaricides, are still exceedingly expensive and often unsustainable. Furthermore, due of the costs and hazards of resistance, cattle producers are hesitant to use acaricides (Darghouth *et al.,* 1994; Achukwi *et al.,* 2001; Coles *et al.,* 2014). As a result, this work will help to the enhancement of tick-borne illness control systems, particularly ECF, as well as the evaluation of various types of control methods used to establish the epidemiological status and identify risk factors for ECF disease.

3 MATERIALS AND METHODS

3.1 Framework for research: The research was conducted in Kabare area, which is located in the north-western part of the province of South Kivu. This location features a humid tropical climate with two seasons at a high altitude. A rainy season and a dry season are the two seasons. The rainy season, on the other hand, lasts from September to May, and the dry season lasts from June to August. The mountainous Kivu gets its name from its mountain relief, which rises from 1450m to more than 3100m in certain locations (Munyuli, 2000). The study environment is depicted in the figure (1) below:

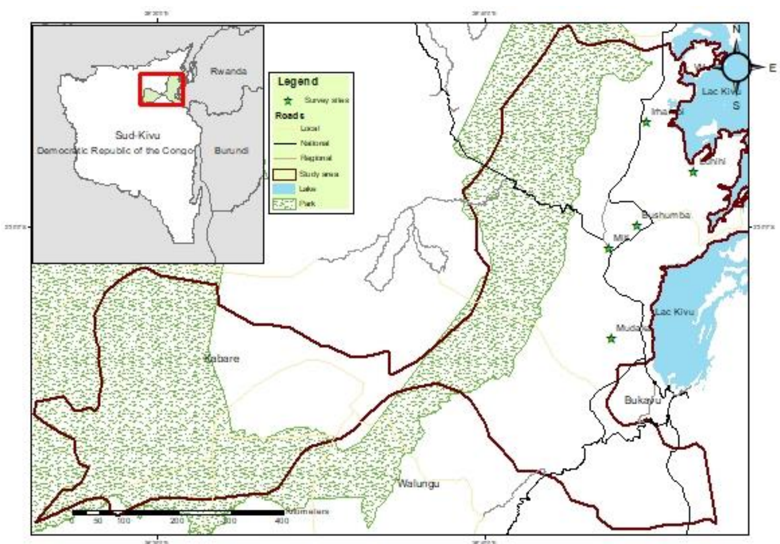

Figure 1: Location of the study environment (GIS-UEA Laboratory, 2020).

The main agricultural activity in Kabare's region is cattle ranching. Cattle graze in pure herds or mixed with small ruminants, such as goats and sheep, on natural grasslands (Masunga, 1994).

3.2 Methods: From January to September 2016, a survey was conducted among several farms. A pre-survey was conducted in October 2015 to identify the specific issues of breeding in Kabare territory because of the prevalence of illnesses, mainly East Coast Fever. A questionnaire was created for this purpose and distributed to 292 breeders or farmers. The criteria for inclusion were farm accessibility, more than 3 years of experience in cattle production, and possessing more than 5 cows, according to the different area called 'groupements'. In addition to collected information about the cattle rearing method, the questionnaire allowed us to collect information about the location of the farm or breeding site; information about the breeder; zootechnical parameters and the epidemiology of the ECF and, finally, the different prophylactics techniques and treatment methods used for this disease

3.3 Statistical analysis

3.3.1 Determination of epidemiological indicators: Epidemiological states are typically identified by epidemiological indices. In cross-sectional research, however, the incidence rates, death rates, and lethality rates are difficult to assess. The risks of incidence and mortality were used instead of their respective rates in this study analysis. As indicated for epidemiological studies and especially for ECF, which shows that if homologous strains are present, an individual cannot be re-infected with the disease (Chartier *et al.,* 2000). Risk is defined as a likelihood with a value ranging from 0 to 1, hence distinct risks have been calculated for each of the three years (2014, 2015, and 2016) as well as the three age groups (Calves : 0-8 months ; Youth cows : 8 months-2 years and Adults cows: Over than 2 years). The data from this study were analysed using Stata 11. For the prevalence of ECF, illness confirmation methods, alternative systems for disease control using medications against *Theileria* sp., the application of acaricides and the use of plants extracts against *Theileria* sp., the application of acaricides and their spending for control, descriptive statistics were created. For the different symptoms of tick-borne diseases, as well as the types of products used to combat parasites and ticks, the logistic regression model was used to calculate the probabilities. As detailed by Saegerman *et al.,* the final risk factor modelling began with the calculation of all variables hypothesized to effect the epidemiology of ECF (2011). It was then followed by a second regression, which used the stepwise criterion at $P>0.05$ to gradually exclude non-significant factors (elimination criterion). As a result, a number of the parameters (case of the livestock system, feeding method, grazing occupation system, acaricide uses, theilericides, plants extracts against ticks and those against *Theileria* sp., grazing time, livestock training) were eliminated due to their high likelihood value.

4 RESULTS

4.1 The prevalence of ECF and the ECF's diagnostic procedures: The survey results in connection to the presence of ECF and the various diagnostic procedures on the various farms are presented in Table 1.

Table 1: The occurrence of ECF and methods of disease confirmation

ECF	**Frequency**	**Percentage (%)**
Absence	12	4.1
Occurrence	280	95.9
Confirmation	**Frequency**	**Percentage (%)**
Laboratory	20	6.84
Clinical signs	272	93.15

According to table 1, bovine theileriosis was diagnosed in 95.9% of farms, with the disease being confirmed primarily through clinical diagnosis (93.15 percent) and only 6.84 percent through laboratory diagnosis.

4.2 Breeders' knowledge of the clinical indications of tick-borne illnesses, especially ECF: The farmers' knowledge of the clinical indicators of tick-borne infections was gathered in order to calculate the likelihood of the various symptoms listed in Table 2 occurring.

Table 2: The probability of onset of symptoms in case of tick-borne diseases (P<0.001)

Observed symptoms	β±SE	P > |Z|	0R (95% CI)	Percentage (%)
Abatement	-	-	-	54.79
Hyperthermia	0.167±0,33	0.616	1.18(0.61-2.27)	58.9
Abortion	-1.81±0,39	<0.001	0.16(0.07-0.35)	16.44
Consumption of excess water	-3.04±0,56	<0.001	0.04(0.01-0.14)	5.48
Constipation	-1.92±0,40	<0.001	0.14(0.06-0.32)	15.06
Bloody diarrhoea	-3.34±0,63	<0.001	0.03(0.01-0.12)	4.11
Drop in production	0.45±0,34	0.177	1.58(0.81-3.08)	65.75
Swelling of lymph nodes	2.22±0,48	<0.001	9.21(3.54-23.91)	91.78
Ictera	-1.72±0,38	<0.001	0.17(0.83-0.38)	17.8
Isolation	-1.72±0,38	<0.001	0.17(0.83-0.38)	17.8
Lacrimation	-1.09±0,34	0.002	0.33(0.16-0.66)	28.77
Non rumination	-0.32±0,33	0.321	0.71(0.37-1.37)	46.57
Non appetite	0.39±0,33	0.239	1.49(0.76-2.89)	64.38
Respiratory disorders	0.71±0,34	0.041	2.04(1.02-4.05)	71.23
LR X^2 =349,17 ; P<0,001				

Legend: LR X^2: Shi^2 value; P: Probability; SE: Standard error; P: P value; 0R (95% CI): Odds ratio at 95% confidence interval.

The table (2) on the clinical signs of tick-borne diseases shows a highly significant difference (P<0.001) between these different symptoms compared to the abatement taken as a reference. The symptoms with the highest frequency of occurrence include parotid lymph node swelling (91.78 percent), respiratory difficulties (71.23 percent), lack of appetite (64.38 percent), and overheating (58.9%). Bloody diarrhoea, increased water consumption, constipation, abortion, Ictera, isolation, lacrimation, and non-rumination, on the other hand, are less common.

4.3 Farmers' perceptions of the various treatments used in the treatment and prevention of tick-borne diseases, particularly ECF

4.3.1 Different disease control systems are used: Vaccination was not adopted as a prophylactic strategy for ECF control by any farmer. When it comes to acaricides, manual spraying is the sole approach used.

Table 3: The different disease control systems

	Use of drugs against *Theileria* sp.		Use of Acaricides	
	Frequency	**Percentage (%)**	**Frequency**	**Percentage (%)**
Non utilization	48	17.1	28	9.6
Utilization	232	82.9	264	90.4
	Use of plants against *Theileria* sp.		**Use of acaricides plants**	
Non utilization	180	61.6	216	74
Utilization	112	38.4	76	26
Expenditure during control by acaricide products				
Average expenditure and its standard deviation			**Expenditure per cow per year**	
83.64 ± 67.905			2.1$	

Among the control methods (Table 3), the most commonly used is acaricide control (90.4%) with an estimated cost of 2.1 dollars per cow per year. The usage of parasite-fighting medications (82.9 percent), parasite fighting plants (38.4 percent), and acaricide plants are the next techniques (26 percent).

4.3.2 Predictions of the probabilities of use of products and plants against *Theileria* sp. and ticks as well as their availability and effectiveness: The results of the study on the use of acaricide products and plants against parasites and ticks are summarized in Table 4 by the various probabilities of use forecasts.

Table 4: Probabilities of using parasite drugs (P<0.001), acaricide products (P<0.001), plants considered acaricides (P=0.001) and estimates of the availability and effectiveness of these control elements.

The probability of using anti-parasite drugs and their availability and effectiveness						
Product Name	**β±SE**	**P > |Z|**	**0R (95% CI**	**Utilization (%)**	**Availability (%)**	**Efficiency (%)**
Buparvaquone	-	-	-	27.4	90	75
Diminazene	-0.21±0.38	0.568	0.80(0.38-1.69)	23.29	17	35
Oxytetracycline	0.94±0.35	0.007	2.57(1.29-5.13)	49.32	37	45
Parvaquone	-1.26±0.47	0.008	0.28(0.11-0.71)	9.59	7	60
LR X^2 = 30.63 ; P<0.001						
The probabilities of using acaricide products, their availability and their effectiveness						
Product names	**β±SE**	**P > |Z|**	**0R (95% CI)**	**Utilization (%)**	**Availability (%)**	**Efficiency (%)**
Avermectine	-	-	-	10.96	50	100
Chorphenvinphos	3.06±0.45	<0.001	21.5(8.7-52.7)	72.6	100	55.55
Coumaphos	-1.05±0.69	0.131	0.34(0.08-1.36)	4.11	100	100
Cypermetrine	1.05±0.45	0.022	2.85(1.16-7.04)	26.03	90	100
Deltametrin	3.28±0.46	<0.001	26.7(10.73-66.7)	76.72	100	67.8
Flumetrine	-0.51±0.59	0.387	0.59(0.18-1.92)	6.8	80	100
LR X^2 =194.15 ; P <0.001						

Probabilities of use of acaricides plants and their effectiveness					
Scientific names	**β±SE**	**P > |Z|**	**0R (95% CI)**	**Utilization (%)**	**Efficiency (%)**
Synadenium grantic	-	-	-	1.37	0
Tephrosia vogelii	0.707±1.23	0.567	2.02(0.17-22.87)	2.54	0
Nicotiana tabacum	1.66±1.10	0.133	5.2(0.60-46.48)	6.05	38
Tetradenia riparia	2.65±1.05	0.012	14.1(1.79-112)	16.44	66.66
LR X^2=15.24 ; P=0.001					
Probabilities of use of plants against the parasite and their effectiveness					
Scientific names	**β±SE**	**P > |Z|**	**0R (95% CI)**	**Utilization (%)**	**Efficiency (%)**
Canabis sativa	-	-	-	9.59	42.85
Clerodendrum myricoides	-1.32±0.81	0.106	0.26(0.05-1.32)	2.73	0
Synadenium grantic	-0.90±0.71	0.203	0.40(0.10-1.62)	4.1	33.33
Leucas martinicensis	-1.32±0.81	0.106	0.26(0.05-1.32)	2.73	0
Nicotiana tabacum	-1.32±0.81	0.106	0.26(0.05-1.32)	2.73	0
Rumex usambarensis	-2.03±1.08	0.030	0.13(0.01-1.09)	1.36	0
Tetradenia riparia	0.89 ± 0.49	0.040	2.43(0.92-6.39)	20.54	60
LR X^2 =28.83; P <0.001					

Legend: LR X^2: Shi² value; P: Probability; **SE**: Standard error; P: P value; 0R (95% CI): Odds ratio at 95% confidence interval.

The probability of drug use against the parasite illustrated in Table 4 shows a highly significant difference (P<0.001) compared to buparvaquone. These results show that Oxytetracycline is the most widely used (β= 0.94±0.35) and burpavaquone is the most available and effective (90% and 75%). As for the use of acaricides, this difference is highly significant (P <0,001) compared to avermectine as a reference product and indicates that the most commonly used are deltametrin (β= 3.28±0.46), chorphenvinphos (β=3.06±0.45) and cypermetrine (β= 1.05±0.45). On the other hand, chorphenvinphos, coumaphos and deltametrin are the most available (100%). The most effective are avermectine, cypermetrine; flumetrine and coumaphos (100%). The plants considered as acaricides (*Tephrosia vogelii* and *Nicotiana tabacum*) by farmers had were commonly used by farmers (P=0.001) as compared to *Synadenium grantic*. *Tetradenia riparia* is the most used (β= 2.65±1.05) and the most effective (66.66%). The probability of using plants against the parasite also shows a significant difference (P<0,001) and underlines that *Tetradenia riparia* (60%) (β=0.89 ± 0.49) is the most widely used and most effective but also *Canabis sativa* (42.85%) and *Synadenium grantic* (33.33%) were used.

4.4 Presentation of epidemiological indicators: The risks of incidence, mortality and lethality rate are considered as factors that determine the different states of the disease. These states of the disease are studied based on retrospective data for the last 3 years (2014; 2015 and 2016) and based on different age groups as presented in table (5).

Table 5: Incidence, mortality and lethality risks of the ECF according to the years (2014; 2015 and 2016) and the different age groups (calves, young cows and adults).

	Impact risk		Mortality risk		Lethality rate	
Years	**β±SE**	**P > |Z|**	**β±SE**	**P > |Z|**	**β±SE**	**P > |Z|**
2014	-	-	-	-	-	-
2015	0.25±0.15	0.095	-0.36±0.36	0.323	-0.61±0.36	0.093
2016	0.14±0.15	0.334	-0.36±0.35	0.306	-0.51±0.35	0.151
LR X² =2.82; P=2.82			LR X² =1.44; P=0.487		LR X² =3.46 ; P=0.177	
Age groups	**β±SE**	**P > |Z|**	**β±SE**	**P > |Z|**	**β±SE**	**P > |Z|**
Adults	-	-	-	-	-	-
Young	-0.22±0.41	0.589	0.01±0.80	0.985	0,23±0,80	0.769
Calves	1.16±0.25	<0.001	0.60±0.62	0.335	-0.55±0,62	0.372
LR X² =22.98 ; P<0.001			LR X² =0.92 ; P=0.632		LR X² =1.17; P=0. 556	

Legend: LR X²: Likelihood shi²; P: Probability; **SE**: Standard error; P: P value; 0R (95% CI): Odds ratio at 95% confidence interval.

With reference to Table 5, the risks of incidence, mortality and mortality rate (P=2.82, P=0.487 and P=0.177) did not change significantly in 2015 and 2016 compared to 2014. A highly significant difference is observed (P<0.001) between young cows and calves compared to adults. It shows that calves (β: 1.16±0.25) has recorded more cases of disease than young cows. However, adult animals did not present a mortality risk (P=0.632) with significant difference compare to young cows and calves.

4.5 Probability of disease incidence based on ECF risk: A number of the parameters have not been considered by the STATA software due to their high probabilities. Hence, this analysis considered only the different 'groupements' (or local division comparable to the district), altitudes of different breeding sites, the breeds of Cows, Pasture area, frequency of acaricide application and veterinary assistance.

Table 6: Final model of the risk factors for ECF incidence

'Groupements'	β±SE	P > |Z|	(IC to 95%)
Bugorhe	-	-	-
Bushumba	0.154±0.424	0.715	-0.677 to 0.987
Irhambi-Katana	-2.01±1.134	0.077	-4.232 to 0.217
Luhihi	-2.65±1.47	0.073	-5.55 to 0.246
Miti	-1.99±0.62	0.001	-3.21 to -0.782
Mudaka	-2.38±0.80	0.003	-3.96 to -0.798
Location of the environment	**β±ES**	**P > |Z|**	**(IC to 95%)**
Altitudes	-0.004±0.003	0.182	-0.01 to 0.002
cow breeds	**β±ES**	**P > |Z|**	**(IC to 95%)**
Brunes suisses	-1.45±1.05	0.167	-3.51 to 0.60
Friesland	1.45±0.52	0.006	0.42 to 2.49
Sahiwal	3.53 ±1.01	0.001	1.54 to 5.53
Ankoles	1.23 ±0.50	0.014	0.25 to 2.22
Crossbred	0.73 ±0.47	0.121	-0.19 to 1.67
Pasture area	-0.02±0.01	0.020	-0.04 to 0.003
Frequency of acaricide application	1.26±0.84	0.136	-0.39 to 2.9
Veterinary assistance	-2.67±1.08	0.013	-4.79 to 0.56
LR X^2= 55.13; P< 0.001			

Legend: LR X^2: Likelihood shi²; P: Probability; **SE**: Standard error; P: P value; 0R (95% CI): Odds ratio at 95% confidence interval.

The table 6 shows a highly significant difference (P < 0.001) in reference to the Bugorhe 'groupement'. The table indicates that the Bushumba 'groupement' (β= 0.154±0.424) has more cases of disease than Miti (β=-1.99±0.62), Irhambi-Katana (β=-2.01±1.13), Mudaka (β=-2.38±0.808) and Luhihi (β=-2.65±1.47). The risk of disease incidence did not differ significantly from the altitude. However, the incidence risks shows that the Friesland, Sahiwal and Ankole breeds (β =1.45 ±0.52; β= 3.53 ±1.01 and β =1.23 ±0.502) have significantly more diseases. The Significant differences were found in the area of pastureland (P =0.020) and veterinary assistance (P=0.013). They indicate that the risk of disease increases as pasture area decreases (β= -0.024±0.01) and is low for farms assisted by a veterinarian (β= -2.679±1.08), unlike the frequency of acaricides, which does not differ significantly.

5 DISCUSSION

According to Masunga *et al.,* Bovine theileriosis caused by *Theileria parva* remains the most common disease occurring in various breeding sites in mountainous Kivu (1989). It has also been confirmed in sections of the Democratic Republic of Congo on the Rwandan boundary (Bazarusanga, 2008). Its occurrence is attributed to rudimentary or non-existent methods of disease diagnosis or confirmation (FAO, 2009; Kalume, 2012). However, symptomatically, this disease is frequently confused with Babesiosis and Anaplasmosis (Kirunda *et al.,* 2012; Muhanguzi *et al.,* 2014). These diseases continue to be the most common tick-borne diseases in various Sub-Saharan African countries, as evidenced by this study in Eastern DRC (Masunga *et al.,* 1989; Kirunda *et al.,* 2012; Muhanguzi *et al.,* 2014). East Coast Fever (ECF) remains the most prevalent disease, owing to the high frequency of inflammation of the parotid glands, which is considered a specific symptom of ECF (Shkap *et al.,* 2010; Tehrani *et al.,* 2013).Other symptoms, such as respiratory problems and social isolation, can be associated with it (Muhammad *et al.,* 1999, FAO, 2006). Anemia associated with bloody diarrhoea, hemoglobinuria, and icterus, on the other hand, is similar to Babesiosis and Anaplasmosis (Minjauw *et al.,* 1997; Mtambo, 2008). Excessive water consumption, on the other hand, can be linked to anaplasmosis because it causes severe dehydration (De Waals, 2000). Furthermore, unlike the red and anaemic mucosa seen in babesiosis, mucosa erosion and weight loss do occur (Darghouth *et al.,* 1994; FAO, 2006). The absence of vaccines in the eastern regions of DR Congo could explain the high prevalence of ECF (Kalume, 2012). As previously stated, this absence is justified by a number of logistical constraints, a lack of understanding among farmers and animal managers, and the costs associated with it (Hakwale *et al.,* 2003; Estrada-Pena et Salman, 2013). Faced with these various restrictions on vaccine usage, the only way to secure the long-term viability of cattle ranching in remote places is to employ medication (Nejash and Tilahum, 2016). This is supported by this study, which shows that oxytetracycline is still the most commonly prescribed medication for ECF. Following its availability and efficacy in the early stages of the disease, this high utilization is obvious (Marcotty, 2003; Shkap *et al.,* 2010). As for the products in the hydroxynaphthoquinone series, buparvaquone and parvaquone are the most used products. These results were also noted by Kalume (2012) and Nene *et al.* (2016). These products from the hydroxynaphthoquinone series represent the most effective drugs against *Theleiria parva* (Nene *et al.,* 2016). Buparvaquone's high utilization in comparison to parvaquone can be explained by its estimated efficacy of 80 and/or 90 times that of parvaquone (Khalaf, 2009; Kalume, 2012). However, unlike oxytetracycline, the widespread use of buparvaquone and parvaquone is limited by their high costs for most livestock farmers, who are unfortunately not even supported by their governments, particularly in developing countries (FAO, 2009; Kalume, 2012). Ectoparasite management methods in Sub-Saharan African countries vary widely, ranging from the use of acaricides and/or repellant oils to phytotherapy (Byavu *et al.,* 2000; Nejash *et al.,* 2016). However, a considerable percentage of cattle farmers are still hesitant to use acaricides due to socioeconomic factors, mainly a lack of information (FAO, 2009). The high expense of these acaricides would also make their application difficult (Gharbi, 2006; FAO, 2009). In addition to tick resistance to acaricides confirmed by Saimo *et al.* (2001); Brooke *et al.* (2010) and Coles and Dryden (2012), the latter is estimated at 2.1$ per year in highland Kivu, significantly below the average of 21$ reported in Kenya and Uganda (Gachohi *et al.,* 2012). Despite the resistance, chorphenvinphos, cypermetrine, and deltametrin continue to be the most commonly utilized. It should be mentioned, however, that deltametrin, as well as coumaphos and Flumetrine, are useless. These findings contrast with those of Monveha (1990) and Nene *et al.* (2016), who found the latter two products to be ineffective. This inefficiency could be related to frequent use, particularly in remote portions of the region, under-dosing, and/or use of these treatments during times when ectoparasite numbers are low (Mekonnen, 2005; Durrey, 2012). The use of plants such as *Tephrosia vogelii*, *Nicotiana tabacum*, *Tetradenia riparia* and *Synadenium grantic* in the control of ticks has been demonstrated. According to Salwa (2010), George *et al.* (2014), and Wanzala *et al.* (2014), the use of these herbs against ticks is explained by their effectiveness. Furthermore, they would allow for the production of repellant oils capable of sticking to cow bodies for long periods of time, reducing acaricide pollution and costs (Schwalbach *et al.,* 2003; Mwendia, 2014). In remote eastern DR Congo locations where contemporary medical supplies are scarce, the use of plants to manage ectoparasites, notably ticks, has a major place (Byavu *et al.,* 2000). A second approach recommends using plants directly on pasture, particularly *Stylosanthes* sp., *Andropogon gayanus*, *Tephrosia vogelii*, and *minuta* (Brooke *et al.,* 2010; Kamago *et al.,* 2010; Kalume, 2012), for a long-term control with the lowest possible cost in the region while limiting the presence of vectors. When it comes to plants that are effective against *Theileria* sp., there is a highly significant difference in the likelihood of their usage, indicating that *Tetradenia riparia*, *Synadenium grantic,* and *Canabis sativa* are the most commonly used and effective. *Tetradenia riparia* has also been shown to be effective (Balagizi *et al.,* 2007). Unlike this study, the work of (Kebenei, 2004; Kamoga *et al.,* 2010; Farah *et al.,* 2014) focuses on the effectiveness of *Clerodendrum myricoides* and *Rumex usambarensis*. Other plants, such as *Stereospermum kunthianum* for *T. parva* in Uganda and *Allium sativum* for *T. annulata*, have shown efficacy in relation to oxytetracycline (Farah *et al.,* 2014; Lutoti *et al.,* 2014). The main epidemiological indicators, particularly the risks of incidence, mortality, and lethality rate, showed no significant differences across research years, particularly 2014, 2015, and 2016, implying that the disease is stable. This state is described as endemic, similar to that reported by Kivaria *et al.* (2004) during the breeding of Ankoles in ranching systems in Uganda, and by Kiara *et al.* (2006) in other smallholders in Kenya, and by Kalume *et al.* (2012) in mixed livestock in North Kivu, DR Congo. In contrast, the substantial differences (Prob<0.001) between these three age groups suggest that calves (β= 1.16±0.25) had higher disease cases than the other age groups (young cows and adults), as documented by Munyaneza (1983) in Rwanda and Thumbi *et al.* (2013) in Kenya, when compared to other diseases. According to Biliouw (2005), this ECF condition can be classified as the second level of endemic stability because the case-fatality rate is around 25%; and even endemic stability according to Marcotty (2003) because the disease incidence is low and the case-fatality and mortality rates are not high. This disease situation in mountainous Kivu is dictated by a number of risk factors, in particular the size of the pasture area, which determines the type of farming (guarding, free range, mixed and zero grazing) or the restriction of calves to grazing before 6 months of age, with a risk of instability of the disease in the event of high mortality, as noted by Bazarusanga *et al.* (2011) and Gachohi *et al.* (2012). This condition is also influenced by disease control systems, which may vary depending on the presence of veterinary assistance and/or different breeds of cattle (Friesland, Sahiwal and Ankoles). This variation was also noted by Gachohi (2009) and would be explained by the fact that the control system influences the interactions between host and ticks resulting in different epidemiological situations of *T. parva* infection (Khalaf, 2009).

6 CONCLUSION AND RECOMMENDATIONS

After completing this study on farmers' opinions of East Coast Fever and risk factors in highland Kivu, it emerges that ECF is the most common symptomatological disease of tick-borne infections, with inflammation of the parotid lymph nodes being the most common symptom. Oxytetracycline, buparvaquone, and parvaquone are used to treat this disease. Parasite control is achieved using phytotherapy, which is dominated by the usage of *Tetradenia riparia*. It also participates in tick control by promoting the use of acaricides. The ECF is endemic in mountainous Kivu, according to epidemiological data. Only the varied 'groupements,' breeds of cattle reared, pasture acreage, and veterinary support, as well as risk variables from the final modelling, influence this state. As a result, the current work will be completed by a biological investigation to clarify the epidemiological state of the ECF so that different control techniques can be adjusted. Specific research on various plants and confirmation of their efficiency in tick management, particularly *Rhipicephalus appendiculatus* and parasite control, are underway (*Theileria parva*). These plants can help with the development of new acaricide and theilericide products, as well as the production of repellent oils, which are necessary to combat acaricide tick resistance and pollution in order to assure cattle safety and long-term breeding.

7 ACKNOWLEDGEMENTS

We would like to thank Professor Tangy Marcotty for providing us with the essential material for this study, as well as all of the farmers in highland Kivu who welcomed us to their farms. We also like to express our gratitude to the Université Evangélique en Afrique (UEA) for providing us with the necessary framework.

8 REFERENCES

Achukwi D., Tanya N., Messine O. et Njongmeta M.2001.Étude comparative de l'infestation des bovins Namchi (*Bos taurus*) et Goudali de Ngaoundéré (*Bos indicus*) par la tique adulte *Amblyomma variegatum*. *Revue d'Élevage et de Médecine vétérinaire des pays tropicaux* (1): 37-4.

Balagizi K., Kambale V. et Emilio R. 2007. Les plantes médicinales du Bushi. *Associazione Insieme al Terzo Mondo Onlu*, Genes-Italie, 315pp.

Bazarusanga T.2008. The Epidemiology of Theileriosis in Rwanda and implications for the control. Thesis of Doctor in Veterinary Sciences (PhD), Department of Virology, Parasitology and Immunology, *Ghent University*-Belgique, 140pp.

Bazarusanga T., Marcotty T., Ahouandjinou K., Ntumba Tshinyama., Katendi C. and Geysen D. 2005. Estimation of the *Theileria parva* entomological inoculation rate (EIR) by means of tick burden and proportion of infected questing ticks in three different farming systems in Rwanda. *International Journal of Vocational and Technical Education Research* (3) 99-106.

Biliouw M. 2005. The epidemiology of bovine theileriosis in the eastern province of Zambia (PhD thesis), Ghent University-Belgique, 139 pp.

Brooke W., Bissinger R. and Michael R.: 2010. Review Tick repellents: Past, present, and future. Carolina State University. *Pesticide Biochemistry and Physiology* (96),63-79.

Byavu N., Henrard C., Dubois M. et Malaisse F. 2004. Phytothérapie traditionnelle des bovins dans les élevages de la plaine de la Ruzizi. *Biotechnologie. Agronomie. Société et Environnement* (3)135–156 .

Chartier C., Itard J., Morel P. et Troncy P.2000. Précis de parasitologie vétérinaire tropicale, *Editions TEC & DOC, Paris, France*,180 pp.

Coles B. and Dryden W.: 2014. Insecticide/acaricide resistance in fleas and ticks infesting dogs and cats. *Parasites & Vectors* (7) 1-10.

Darghouth A., Bouattour A., Miled B., Kilani M. et Brown C. 1999. Études épidémiologiques sur la Theilériose bovine à *Theileria annulata* : Application à la caractérisation du type endémique et à la définition d'une stratégie de lutte. Dans la Biotechnologies du diagnostic et de la prévention des maladies animales(ed). AUPELF-UREF. John Libbey Eurotext. Paris.9pp.

De Waals D. 2000. Anaplasmosis Control and Diagnosis in South Africa. *Annals of the New York Academy of Sciences* (916) 474-483.

Durrey K.2012. Syndrome paralysie dû aux morsures de tiques chez les ruminants. Étude bibliographique, École vétérinaire d'Alfort, Thèse pour doctorat vétérinaire, 143pp.

Estrada-Peña A. and Salman M. 2013. Current Limitations in the Control and Spread of Ticks that Affect Livestock*: A Review. Agriculture* (3) 221-235.

FAO.: 2006. Bonnes pratiques pour l'industrie de la viande, FAO production et santé animales manuel, ISBN 978-92-5-205146-5, 326 pp.

FAO. 2009. La situation mondiale de l'alimentation et de l'agriculture, le point sur l'élevage, ISSN 0251-1460, 202 pp.

Farougou S., Kpodekon V. et Tassou W.2007. Abondance saisonnière des tiques (Ixodidae) parasites des bovins dans la zone soudanienne du Bénin, cas des départements du Borgou et de l'Alibori. *Revue Africaine de Santé et de Productions Animales* (5) 61-67.

Farah M., Tigani H., Hassan E. and Rahim M. 2014. Antitheilerial Herbal Medicine: A Review. *Biotechnology Journal International* (7) 817-828.

Gachohi M. 2009. Estimating the Seroprevalence of *T. Parva* infection and determination of associated risk factors in the cattle population of Mbeere District, a thesis submitted in partial fulfilment of the requirements for the award of a degree in Master of Science in Veterinary Epidemiology and Economics, Kenya (BVM, Nairobi), 137 pp.

Gachohi J., Skilton R., Hansen F., Priscila N. and Kilata P. 2012. Epidemiology of East coast fever (*Theileria parva* infection) in Kenya: Past, present and the future. *Parasites & Vectors* (5)1-13.

George R., Finn D., Graham M. and Sparagano A. 2014. Present and future potential of plant-derived products to control arthropods of veterinary and medical. *Parasites & Vectors* (7) 1-12.

Gharbi M. 2006. Vaccination contre la theilériose tropicale en Tunisie (*Theileria annulata*). Analyse économique et essai d'immunisation par ADN/ N° d'ordre, 158pp.

Hakwale M., Mangani P., Fujisaki K. and Nagasawa H. 2003. The current status of major tick borne diseases in Zambia. *Veterinary Research* (34) 27-45.

Khalaf G.:2009. Evaluation of Buparvaquone in the treatment of Theileria annulata in Calves. *Al-Anbar Journal Veterinary Sciences* (2) 14-18.

Kalume K. 2012. Épidémiologie et contrôle de la Theilériose bovine à *Theileria parva* dans la Province du Nord-Kivu, République Démocratique du Congo, Thèse, Presses de la Faculté de Médecine vétérinaire de l'Université de Liège, 212pp.

Kalume K., Saegerman C., Marcotty T., Duchatel J. et Losson B. 2012. Statut épidémiologique de l'East Coast Fever (ECF) dans deux troupeaux de bovins issus de systèmes d'élevage distincts au Nord-Kivu, République démocratique du Congo. *Annales Médecine Vétérinaire* (156) 99-108.

Kamoga D. 2010. Some pharmacological activities of selected medicinal plant species used for treating cattle diseases in Kabira sub-county, a dissertation submitted to the school of graduate studies for the award of a degree of Master of Science (botany) of Makerere University, 66pp.

Kebenei S., Ndalut K. and Kiprono P.:2004. Short communication larvicidal activity of myricoidine from *Clerodendrum myricoides*. *Bulletin of the Chemical Society of Ethiopia* (18) 225-227.

Kiara H., O'Callaghan C., McDermott J. and Perry B.2006. A study of the epidemiologic states of theileriosis in a range of smallholder dairy farms in Kenya. Proceedings of the 11th international Symposium on veterinary epidemiology and Economics. Available at www.sciquest.org.nz..

Kirunda H., Kabi F., Muwereza N., Kabuuka T., Magona W. and Lukwago G.2012. Knowledges and perceptions of smallholder dairy farmers of cattle disease burdens in selected agro-ecological zones of Uganda. *Uganda Journal of Agricultural Sciences* (2) 107-116.

Kivaria M., Heuer C., Jongejan F., Okello-Onen J., Rutagwenda T., Unger F., Boehle W. 2004. Endemic stability for *Theileria parva* infections in Ankole calves of the Ankole ranching scheme, Uganda. *Journal of Veterinary Research* (71)189–195.

Lutoti S., Anyama G., Iberet J., Bamuwamye M., Kwiringira W., Aber J., Nambejja C .,Agwaya M., Okia C., Nambatya K., Ogwang P. and Onegi B. 2014. Evaluation of Anti-theilerial Activity of A lipophilic Root Bark Extract of

Stereospermum kunthianum against *Theileria parva*. *Collections of the School of Bio-Medical Sciences*. http://hdl.handle.net/10570/4712.

Marcotty T. 2003. Optimisation et rationalisation de l'immunisation du bétail de la Zambie de l'Est contre *Theileria parva*. Thèse de doctorant en Sciences Vétérinaires, 209 pp.

Masunga M., Sika K. et Wabo B. 1989. Recherches sur les tiques et maladies qu'elles transmettent au bétail dans le Kivu d'Altitudes/CRSN/Lwiro, Est du Zaïre (RDC).Notes scientifiques. *Rapport anal.* 3p.

Masunga M. 1994. Etude épidémiologique de la Theilériose des bovins dans les groupements d'Irhambi et de Bugorhe, Kabare, Sud-Kivu, Est-Zaïre. *Revue Scientifique* (2) 59-63.

Marcellino W., Salih D., Julla I. and EL Hussein A. 2011. Economic Impact of East coast fever in central equatorial state of South Sudan. *International Research Journal of Agricultural Science and Soil Science* (1) 218-220.

Mekonnen S. 2005. Acaricides resistance profiles of single and multi-host ticks in commercial and communal farming areas in the Eastern Cape and North West provinces of South Africa, University of Pretoria (ed), 139 pp.

Minjauw B., Otte M. and James A. 1997. Incidence of clinical and sub-clinical *Theileria parva* infection in Sanga cattle kept under different ECF control strategies in Zambia, *Epidemiologie Santé animale* (2)715-730.

Monvèha H. 1990. Lutte contre les tiques parasites des bovins en République du Benin: Essai d'utilisation ou Bayticol pour on (Flumethrine) dans la province du Borgou, Université Cheikh Antadiop, 156 pp.

Mtambo J. 2008.*Rhipicephalus appendiculatus/zambeziensis* complex from southern and eastern Zambia: genetic and phenotypic diversity related to the associated variation of the epidemiology of bovine theileriosis, *Diergeneeskunde Universiteit Gent*, 250pp.

Muhammad G., Saqib M., Khan Z. and Aqi N. 1999. Clinnico-epidemiological and therapeutic aspects of bovine theileriosis. *Pakistan Veterinary Journal* (2)64-71.

Munyaneza C. 1983. La pathologie du veau nouveau-né au Rwanda présenté à la faculté de Médecine ET de Pharmacie de Dakar, Travail pour obtenir le grade de docteur vétérinaire, 150 pp.

Muhanguzi D., Picozzi K., Hatendorf J., Thrusfield M., Welburn S., Kabasa J. and Waiswa C.2014. Prevalence and spatial distribution of *Theileria parva* in cattle under crop-livestock farming systems in Tororo District, Eastern Uganda, *Parasites and Vectors* (7)1-8.

Munyuli T. 2000. Etude préliminaire orientée vers la production des chenilles consommables par l'élevage des papillons (*Anaphe infracta: Thaumetopoeidae*) à Lwiro, Sud-Kivu. RDC. *Tropicultura* (18) 208-211.

Mwendia M., Kosgei J., Mwaniki G. and Matasyoh C.2014. Phytochemical screening, cytotoxicity studies and larvicidal activity of hexane extract of *Lippia kituiensis* against *Rhipicephalus appendiculatus*. *Journal of Biomedical and Pharmaceutical Research*. (4)105-110.

Nejash A. and Tilahun A. 2016. Epidemiology and Control of Bovine Theileriosis in Ethiopia: Review. *Journal of Medical Physics and Biophysics* (23) 32-44.

Nene V., Kiara H., Lacastra A., Pelle R., Svitek N. and Steinaa L.: 2016. The biology of *Theileria parva* and control of East Coast Fever -Current status and future trends. *Ticks Tick borne Diseases* (7) 549-564.

SchwalbachJ., Greyling C. and David M. 2003. The efficacy of a 10% aqueous Neem (*Azadirachta indica*) seed extract for tick control in small East African and Toggenburg female goat kids in Tanzania. *South African Journal of Animal Science* (33) 83-89.

Saegerman C. et Ludovic M. 2011. Importance des facteurs de risque dans l'expression clinique des maladies infectieuses chez les ruminants, *Unité de Recherche en Epidémiologie et Analyse de Risques appliquées aux Sciences Vétérinaires* (UREAR).12 pages .

Saimo M., David O., Mwaura S., Vlak M., Musoke J., Lubega W., Richard P. and Monique M. 2011. Recombinant *Rhipicephalus appendiculatus* gut (ra86) and salivary gland cement (trp64) proteins as candidate antigens for inclusion in tick vaccines: protective effects of ra86on infestation with adult *R. appendiculatus*, in Vaccine: *Development and Therapy* (1) 15-23.

Salwa M. 2010. Ethno-veterinary and medical knowledges of crude plant extracts and its method of application (traditional and modern) for tick control. *World Applied Sciences Journal.* (9)1047-1054.

Shkap V., Leibovich B., Krigel V. and Fish P.2010. Evaluation of combined formulation of parvaquone and frusemide (fruvexon) in the treatment of experimental tropical theileriosis. *International Journal Applied Research in Veterinary Medicine* (1) 77-73.

Tehrani A., Hosseini E. and Bahrami M. 2013. Biochemical, hematological studies in cattle naturally infected with *Theileria annulata. Bulletin of Environment, Pharmacology and Life Sciences* (2) 07-10.

Thumbi M., Bronsvoort M., Kiara H., Toye G., Poole J., Ndila M., Conradie I., Jennings A., Handel G., Coetzer J., Steyl J., Hanotte O. and Woolhouse M. 2013. Mortality in East African shorthorn zebu cattle under one year: predictors of infectious-disease mortality. *BMC Veterinary Research* (9)1-14.

Wanzala W., Hassanali A., Mukabana W. and Takken W.2012. Repellent activities of essential oils of some plants used traditionally to control the brown ear tick, *Rhipicephalus appendiculatus*. *Journal of Parasitology Research* 1-10.