SPATIAL AND TEMPORAL DYNAMICS OF TICK INFESTATION OF SHEEP IN MIXED GRAZING (SHEEP AND CATTLE) AREAS OF THE BAMBOUTOS DIVISION, WEST REGION OF CAMEROON

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ABSTRACT

Several species of ticks represent the health and productivity problems of sheep in Cameroon. This study aimed to investigate the dynamics of tick infestation on sheep in mixed grazing sheep and cattle areas of the Bamboutous Division, West region of Cameroon. A longitudinal study was carried out from April 2022 to February 2023 on 504 sheep reared in mixed grazing with cattle. Sheep were selected using standard sampling methods, characterized by gender and age, and inspected for tick collection. All visible ticks were collected on each animal, preserved in 70% ethanol, counted and identified morphologically. In total, 2470 ticks belonged to 14 species and grouped in 4 genera were identified namely: Rhipicephalus (79.51%), Amblyomma (12.75%), Ixodes (7.53%) and Haemaphysalis (0.2%). 05 species were cattle species namely: R. guilhoni, I. pilosus, R. muhsamae, R. lunulatus and R. sinus. The invasive tick R. microplus was found on sheep during the two seasons. Of the 504 animals examined, 306 (60.71%) were infested and the mean tick count was 9.77 ± 1.37. The frequency of some species was significantly different according to altitude. Animals were more infested in the rainy season (71.2%) than in the dry season (28.8%). This assessment showed that many tick species hinder the development of sheep productivity in the mixed grazing area of the Bamboutos Division. Farmers must be made aware of the importance of tick control to reduce or avoid losses due to ticks.

Keywords: Ticks, Ruminants, Pasture, Productivity, Central Africa

INTRODUCTION

Ticks are grouped in certain genera of arthropods (*Rhipicephalus*, *Ambyomma*, *Haemaphysalis*, *Ixodes, Hyalomma*) (Walker *et al.*, 2003) and constitute hazards to the health, growth and productivity of sheep breeding in Cameroon (Malla *et al.*, 2021). Nowadays, almost 900 species of ticks have been identified and belong to three families namely: *Nuttalliellidae* (with a single genus and species), *Ixodidae* or hard ticks (including 14 genera and about ~700 species) and *Argasidae* or soft ticks (with 5 genera and about ~200 species) (Guglielmone *et al.*, 2010).

Tick infestation leads to important direct and indirect losses of agriproducts stored and in the field. The former losses include damage to tick bite-related hides and skin in heavily infested animals, anaemia and severe allergic reactions due to saliva toxins, loss of energy due to

constant movement during scraping, chronic stress and irritation that leads to immune depression. The indirect losses include costs arising from treatment, tick control, acaricide-contaminated animal products, loss of weight leading to low prices on the market and losses arising from the effects of ticks-transmitted pathogens (Kasaija *et al*., 2021). Pathogens transmitted are responsible for tick-borne diseases such as anaplasmosis, babesiosis, theileriosis, mycoplasmosis and coxiellosis (Acha, 2003; Onyiche and MacLeod, 2023). The consequences on the production of sheep are growth retardation, mortality (reaching 6.1% in lambs not weaned and 20% in weaned lambs in tropical environments) (Hounzangbe-Adote *et al*., 2001), weight loss (reaching 15 to 20 Kg) and reduced milk production in lactating female (Hurtado and Giraldo-Ríos, 2018).

Transboundary animal movements in sub-Saharan Africa favour the introduction, establishment, and spread of exotic ticks and their pathogens in previously free areas. This is the case of the cattle tick *Rhipicephalus (Boophilus) microplus,* a vector of *Babesia bovis*, which is thought originated in Brazil and then rapidly spread to many other West African countries (Madder *et al*., 2007; 2012) and Central African countries, including Cameroon recently (Silatsa *et al*., 2019; Lontsi-Demano *et al.,* 2020; Sado Yousseu *et al.,* 2022). This tick first settled in cattle and then in small ruminants especially sheep (Madder *et al*., 2007; Sado Yousseu *et al.,* 2022).

Tick control involves the use of acaricides, manual tick removal and modification of the tick's biotope (Hurtado and Giraldo-Ríos, 2018). The study of the dynamics of tick species is necessary for the proper animal care and the preparedness of the response in the event of an epizootics. Also, the identification of tick species, their abundance, and distribution, is of great importance to understanding the epidemiology of tick-borne diseases, the effects of ticks, and their control for the different ecological zones (Taheri *et al.,* 2014; Silatsa *et al*., 2019). However, studies conducted on ticks infesting sheep in Cameroon have been limited to certain regions such as the North-West, South, South-West and Central Regions (Mbuh *et al*., 2008; Kouam and Dongmo, 2018; Malla *et al*., 2021; Sado Yousseu *et al.,* 2022). The West Region of Cameroon remains largely understudied regarding tick infestation, despite being an important meat-producing hub in the country (Lamnyam *et al.,* 2022). The slopes of Mount Bamboutos a famous mountain in Cameroon, have been used for grazing activities for several decades. Most of the sheep reared in these areas often graze in the same pasture as the cattle. Mixed grazing cattle and sheep is recommended for reducing gastrointestinal helminth parasites in sheep (Marley *et al*., 2006). However, to the best of the author's knowledge, no study has been conducted to evaluate the impact of mixed grazing (cattle and sheep) on tick infestation of sheep in Cameroon. The present study investigated the identification and dynamic of ticks in sheep reared in mixed grazing (sheep and cattle) in Bamboutos Division, West Cameroon.

MATERIALS AND METHODS

Study Area: This study was carried out in Bamboutos Division (5°37'N 10°15'E), in the West Region of Cameroon. The area is characterised by a sub-tropical climate with two seasons: a rainy season, from March to October and a dry season, from November to February. Annual rainfalls are moderated and range from 1700 to 2000 mm with an average of 1850 ± 150 mm. The average yearly temperature is 20.4°C and fluctuates between 11 and 29.9°C at daytime (MINEF, 1999). The vegetation is subdivided into three types: tropical wooded savannah in the valleys, shrubby grassland in the mountains and dense forest on its southern slopes. Agriculture, livestock rearing, and small-scale trade are the main economic activities carried out by the local population in this division (ASBAI, 2017). Farmed animals include cattle, sheep, goats, pigs and poultry (Kumar *et al.,* 2013).

Study Sites: Four villages were selected in the study area, two located in low altitudes and two located in high altitudes. Bagam (05°45.523'N 010°22.074'E; 1256 m of altitude) and Bamignam (05°46.263'N 010°21.449'E; 1281 m of altitude) were located in the low altitude area, while Bamelo (05°41.025'N; 010°06714'E; 2364

m of altitude) and Bangang (05°36.899'N; 010°06.201'E; 2135 m of altitude) were located in the high-altitude area (MINEF, 1999). Pastures in the low altitude area are characterised by wooded savannahs sometimes transformed into food crops, with an average temperature of 22°C. The sheep raised there are of the Djallonké breed. Regarding the high-altitude area, pastures are represented by grass-rich shrub meadows, with cool temperatures fluctuating from 11 to 18°C. The sheep raised there are of the Sahelian breed (Coton breed and Oudah breed).

Sheep Sampling on the Field: Sheep of all ages grazing in the Bamboutos Division were included in the study. The field trips were carried out from April 2022 to February 2023 covering the rainy and dry seasons. On the spot, animals were systematically selected using the "sampling interval technique". Briefly, the first animal was randomly selected and constituted the origin of the sampling step while the rest of the animals were chosen at a rate of "4" (three animals separated from the first to the next and so on) (Lontsi-Demano *et al.,* 2020). Indeed, animals were kept in small enclosures and a count was carried out in which the numbers 1, 5, 9 and so on were marked and then formed the sample.

The age of the sheep was determined by teeth examination. Sheep with no adult incisors were considered as lambs; those with one to two pairs of adult incisors were considered as juveniles and those with three or more pairs of incisors were considered as adults. Added to the determination of the age of the sheep, sex and breeds were also recorded.

Ticks Sampling on Sheep and Storage: The collection of ticks was performed on each sheep included in the study using the manual tick removal technique. They were restrained, kept standing and all the body parts were examined and only visible ticks were plucked using blunt steel forceps taking care not to damage the mouthparts. For each animal and each body part, ticks collected were preserved in labelled tubes containing 70% ethanol.

Morphological Identification of Tick Species: Morphological identification of the ticks at the species level was performed according to criteria defined by Walker *et al.* (2003). Specimens were observed in a stereomicroscope (branded Euromex Edublue series 3 NI-MH) at the magnification of 2 and 4. The following body parts of tick were used for identification: capitulum, caudal appendage, cervical field, scutum, coxae, and hypostomal teeth.

Data Analysis: Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) software version 20.0 for Windows (SPSS, IBM, Incorporated, California, USA). Descriptive statistics were used to compute the distribution of tick species. Pearson's chi-square test (χ^2) was used to compare the percentages of infestation, while Kruskal-Wallis's test was used to compare the mean tick count. P-values less than 0.05 were considered statistically significant.

RESULTS

Composition of Tick Fauna of Mixed Grazing Sheep in Bamboutos Division: A total of 2470 ticks were collected on 306 sheep. Ticks were classified into 4 genera belonging to *Rhipicephalus* - 1964 ticks (79.51%), *Amblyomma* - 315 ticks (12.75%), *Ixodes* - 186 ticks (7.53%) and *Haemaphysalis* - 5 ticks (0.2%). The sample consisted of the following 14 species: *Rhipicephalus guilhoni* (24.37%), *Rhipicephalus boophilus decoloratus* (20.49%), *Amblyomma variegatum* (12.75%), *Rhipicephalus evertsi* (7.69%), *Ixodes pilosus* (7.53%), *Ripicephalus boophilus. annulatus* (7%), *Rhipicephalus boophilus geigyi* (5.83%), *Rhipicephalus boophilus microplus* (3.93%), *Rhipicephalus sanguineus* (2.92%), *Rhipicephalus muhsamae* (1.78%), *Rhipicephalus lunulatus* (1.38%), *Haemaphysalis punctate* (0.2%), *Rhipicephalus sinus* (0.04%) and *Rhipicephalus* spp. (4%). The most abundant species was *R. guilhoni* (24.37%) and the less abundant species was *R. sinus* 1(0.04%). The tick population was dominated by adult stages (67.12%; n = 1658) representing 2/3 of the population (Table 1).

Infestation Rate and Mean Tick Count: Out of the 504 sheep examined, 306 were infested by at least one species of tick yielding an overall frequency of 60.71%.

Table 1: Ticks abundance in sheep per genus, species and development stages in mixed grazing areas of the Bamboutos division, Cameroon

Genera and Species	Development stages			Total n(%)
	Larvae n(%)	Nymphs n(%)	Adults n(%)	
Genera				
Amblyomma	2(0.63)^{a2}	156(49.52)^{b4}	157(49.84)^{b3}	315(12.75)
Rhipicephalus	487(24.8)^{b4}	127(06.47)^{a3}	1350(68.73)^{c4}	1964(79.51)
Ixodes	12(06.45)^{a3}	28(15.05)^{b2}	146(78.49)^{c2}	186(7.53)
Haemaphysalis	0(0.00)^{a1}	0(0.00)^{a1}	5(100)^{b1}	5(0.2)
Species				
A. variegatum	2(0.63)^{a2}	156(49.52)^{b7}	157(49.84)^{b6}	315(12.75)
R. microplus	31(31.96)^{b6}	12(12.37)^{a2}	54(55.67)^{c4}	97(3.93)
R. decoloratus	315(62.25)^{c8}	29(05.73)^{a4}	162(32.01)^{b6}	506(20.49)
R. geigyi	13(09.02)^{a4}	36(25)^{b5}	95(65.97)^{c5}	144(5.83)
R. annulatus	27(15.6)^{a5}	50(28.9)^{b6}	96(55.49)^{c5}	173(7)
R. muhsamae	0(0.00)^{a1}	0(0.00)^{a1}	44(100)^{b3}	44(1.78)
R. lunulatus	0(0.00)^{a1}	0(0.00)^{a1}	34(100)^{b3}	34(1.38)
R. guilhoni	0(0.00)^{a1}	0(0.00)^{a1}	602(100)^{b8}	602(24.37)
R. evertsi	0(0.00)^{a1}	0(0.00)^{a1}	190(100)^{b7}	190(7.69)
R. sanguineus	0(0.00)^{a1}	0(0.00) ^{a1}	72(100)^{b4}	72(2.92)
R. sinus	0(0.00)^{a1}	0(0.00)^{a1}	1(100)^{b1}	1(0.05)
I. pilosus	12(06.45)^{a3}	28(15.05)^{b3}	146(78.49)^{c6}	186(7.53)
H. punctate	0(0.00)^{a1}	0(0.00)^{a1}	5(100)^{b2}	5(0.2)
***Rhipicephalus* spp.**	101(100)^{b7}	0(0.00)^{a1}	0(0.00)^{a1}	101(4)
Total	501	311	1658	2470

n = number of ticks counted, values in parenthesis = percentages, $^{1-8}$ = values with different number superscripts along a column are significantly different ($p<0.05$), $^{a-c}$ = values with different letter superscripts along a row are significantly different ($p<0.05$)

The most frequent species was *A. variegatum* (35.6%) (Table 2). The mean tick count was 9.77 ± 1.37 and the species with the high mean tick count was *R. b. decoloratus* (10.54 ± 7.32) (Table 2).

Tick Frequency and Mean Count According to Season: Animals were more infested in the rainy season (71.2%) than in the dry season (28.8%) (Table 2). *A. variegatum* was the most frequent species in the rainy season while in the dry season it was *Ixodes pilosus*. *Amblyomma* spp. and *Boophilus* spp. infested sheep during the two seasons while the other *Rhipicephalus* spp. and *Ixodes* spp. infested sheep only during one season: the first in the rainy season and the second in the dry season. The mean tick count was also higher in the rainy season (10.72 ± 1.77) than in the dry season (7.35 ± 1.43) (Table 2).

Tick Frequency and Abundance According to Altitude: The frequency of infestation did not globally vary according to altitude. However, the distribution of some species varied between altitudes. *R. guilhoni* and *R. sanguineus* were 8 times and 3 times respectively more frequent and more abundant in high-altitude areas than in low-altitude areas while *A. variegatum* and *I. pilosus* were 2 times more frequent and more abundant in low-altitude areas than in high-altitude areas (Table 3).

Tick Frequency and Mean Count According to Sheep Parameters: The sheep parameters studied were sex, breed and age. The frequency of infestation varies according to sex, breed and age groups (Table 4). On the other hand, the mean tick count was higher in adult sheep (11.98 ± 1.7) than in lambs (9.81 ± 2.8) and in juveniles (8.31 ± 0.8).

Dermatophilosis Frequency According to Season, Altitude and Sheep Parameters: Dermatophilosis was observed in 14.7% (N = 45) of infested sheep. It was more frequent in the rainy season (86.7%; N = 39) than in the dry season (13.3%; N = 6). Dermatophilosis was also more frequent in mountainous areas (66.7%; N = 30) than in valleys (33.3%; N = 15). It was low in Coton breed (8.9%) than in Djallonké (33.3%) and Oudah (57.8%) (Table 4).

Table 2: Tick frequency and mean count in sheep according to species and seasons sampled from mixed grazing areas of the Bamboutos division, Cameroon

Tick species	Frequency of infestations N(%)			Mean tick count ± SD		
	Total	Rainy season	Dry season	Total	Rainy season	Dry season
A. variegatum	109(35.6)[8]	101(92.7)[8]*	8(07.3)[4]	2.90 ± 0.21	3.03 ± 0.22*	1.25 ± 0.16
R. microplus	20(6.5)[2]	13(65.0)[3]	7(35.0)[3]	4.85 ± 1.21	4.23 ± 1.45	6.0 ± 2.26
R. decoloratus	48(15.7)[5]	36(75.0)[5]	12(25.0)[5]	10.54 ± 7.32	16.69 ± 9.76*	4.08 ± 1.29
R. geigyi	34(11.1)[4]	22(64.7)[4]	12(35.3)[5]	4.24 ± 1.18	3.05 ± 0.61	6.42 ± 3.15*
R. annulatus	23(7.5)[2]	8(34.8)[2]	15(65.2)[6]*	7.52 ± 2.7	3.38 ± 0.77	9.73 ± 4.05*
R. muhsamae	31(10.1)[3]	31(100)[5]*	0(0.00)[1]	1.45 ± 0.18	0.00 ± 0.00	0.00 ± 0.00
R. lunulatus	20(6.5)[2]	20(100)[4]*	0(0.00[1]	1.70 ± 0.33	0.00 ± 0.00	0.00 ± 0.00
R. guilhoni	61(19.9)[6]	61(100)[7]*	0(0.00)[1]	9.87 ± 1.16	0.00 ± 0.00	0.00 ± 0.00
R. evertsi	49(16.0)[5]	48(98.0)[6]*	1(2.0)[2]	3.90 ± 0.46	3.51 ± 0.49*	1.00 ± 0.00
R. sanguineus	22(7.2)[2]	21(95.5)[4]*	1(4.5)[2]	3.27 ± 0.52	3.38 ± 0.53*	1.00 ± 0.00
R. sinus	1(0.3)[1]	1(100)[1]	0(0.00)[1]	1.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
I. pilosus	68(22.2)[7]	1(01.5)[1]	67(98.5)[7]*	2.74 ± 0.38	1.00 ± 0.00	2.76 ± 0.39*
H. punctata	1(0.3)[1]	1(100)[1]	0(0.00)[1]	5.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Total	306(100)	218(71.2)	88(28.8)	9.77 ± 1.37	10.72 ± 1.77	7.35 ± 1.43

*N = number of infested animals, SD = Standard deviation, values in parenthesis = percentages, [1-8] = values with different number superscripts along a column are significantly different (p<0.05), * = values with an asterisk are significantly different (p<0.05) using student t-test pairwise comparison*

Table 3: Tick frequency and relative abundance in sheep according to altitude in mixed grazing areas of the Bamboutos division, Cameroon

Tick species	Frequency N(%)		Relative abundance n(%)	
	High altitude	Low altitude	High altitude	Low altitude
A. variegatum	36(33.0)[7]	73(67.0)[8]*	84(26.67)[6]	231(73.33)[7*]
R. B. microplus	07(35.0)[1]	13(65.0)[4*]	28(28.86)[2]	69(71.13)[3*]
R. B. decoloratus	17(35.4)[5]	31(64.6)[6*]	44(8.7)[4]	462(91.3)[8*]
R. B. geigyi	20(58.8)[6]	14(41.2)[4]	88(61.11)[6*]	56(38.89)[3]
R. B. annulatus	09(39.1)[2]	14(60.9)[4]	37(21.39)[3]	136(78.61)[5*]
R. muhsamae	13(41.9)[3]	18(58.1)[5]	17(38.64)[1]	27(61.36)[2]
R. lunulatus	09(45.0)[2]	11(55.0)[3]	16(47.05)[1]	18(52.94)[1]
R. guilhoni	54(88.5)[8*]	07(11.5)[2]	590(98)[8*]	12(1.99)[1]
R. evertsi	18(36.7)[5]	31(63.3)[6*]	102(53.68)[7]	88(46.31)[4]
R. sanguineus	16(72.7)[4*]	6(27.3)[1]	51(70.83)[5]	21(29.16)[2]
I. pilosus	20(29.4)[6]	48(70.6)[7*]	41(22.04)[4]	145(77.95)[6*]
Total	134(43.8)	172(56.2)	1105(44.73)	1365(55.26)

*N = number of infested animals, n = number of ticks counted, values in parenthesis = percentages, [1-8] = values with different number superscripts along a column are significantly different (p<0.05), * = values with an asterisk are significantly different (p<0.05) using student t-test pairwise comparison*

Table 4: Tick frequency, mean count and dermatophilosis based on sex, breeds and age groups of sheep sampled from mixed grazing areas of the Bamboutos division, Cameroon

Category	Number of Animals infected	Frequency (%)	Dermatophilosis N(%)	Mean tick count ± SD
Sex				
Male	77	25.2	11(24.4)	11.34 ± 4.1
Female	229*	74.8*	34(75.6)*	9.23 ±0.7
Breeds				
Coton	13	4.2	4(8.9)^{a}	10.85 ± 2.4
Oudah	122	55.9	26(57.8)^{c}	9.79 ± 1
Djallonké	171	39.9	15(33.3)^{b}	9.72 ± 2.2
Age groups				
Lambs	135	44.1	19(42.2)	9.81 ± 2.8^{b}
Juveniles	106	34.6	12(26.7)	8.31 ± 0.8^{a}
Adults	65	21.2	14(31.1)	11.98 ± 1.7^{c}

*N = number of infested animals, values in parenthesis = percentages, SD = Standard deviation, $^{a-c}$ = values with different letter superscripts are significantly different ($p<0.05$), * = values with an asterisk are significantly different ($p<0.05$) using student t-test pairwise comparison*

Ticks Range on the Sheep: Ticks were collected on several body parts of sheep: auricle (39.54%), legs (29.41%), abdomen (16%), anus and tail (13.72%), udder and testicles (12.41%), head (3.59%) and others (back, eyes and neck: 8.49%). The most parasitic body part was the auricle (39.54%). However, the different species collected preferred to attach to specific body parts of animals. For example, *A. variegatum* and *I. pilosus* were mostly found on the legs while *R. guilhoni* and *R. evertsi* were mostly found on the auricle (Table 5).

DISCUSSION

In this survey, a total of 2470 ticks were collected from 306 sheep yielding an overall frequency of 60.71%. This high frequency might be due to poor management systems. Sheep in Bamboutos are left in continuous grazing in the same pasture. As a result of this, animals re-infested themselves continually in pasture. In addition, breeders encountered difficulties to fighting against ticks, difficulties due to the high cost of acaricides, the limits of their use as recommended by the manufacturers, the availability of effective molecules amongst counterfeit products and the development of resistance in tick population (Lontsi-Demano *et al.,* 2020).

The tick fauna was constituted of 14 tick species. This diversity is greater than that revealed by Malla *et al.* (2021) in the northwest region of Cameroon (six species) and Kouam and Dongmo (2018) in the southern region of Cameroon (three species). The high diversity observed in western Cameroun may be because sheep of this area often share the same pastures as cattle, where cattle may have contaminated them with tick species that are receptive to sheep. This would be the case of *R. guilhoni*, *I. pilosus*, *R. muhsamae*, *R. lunulatus* and *R. sinus*, identified in West Region cattle. Additionally, the agroecological zone of the Western highlands has a climate which favours the installation of a significant plant cover and a litter of abundant dead leaves which proves to be a favourable environment for the development and maintenance of ticks (Lontsi-Demano *et al.,* 2020). The presence of these cattle tick species in sheep could lead to an increase in the prevalence and incidence of tick-borne diseases in this area.

R. guilhoni, R. b. decoloratus and A. variegatum, were the most abundant species infesting sheep in this study. *R. guilhoni* was also the third most common species. It is not known whether this species of tick is associated with any tick-borne disease (Walker *et al.*, 2003). It is a three-host life cycle tick with the immature stages feeding on rodents. Its frequency and abundance which are most important can be explained by the fact that the sheep of the study area are reared on open land which increases the likelihood of contact with questing ticks. The abundance of *R. b. decoloratus* may be due to their enormous reproductive potential and the simplicity of their life cycle which is monoxene (the three developmental stages feed on a single host type).

Table 5: Tick frequency according to the specific body parts of sheep in mixed grazing areas of the Bamboutos division, Cameroon

Ticks' species		Body parts						
	N	Head N(%)	Abdomen N(%)	Udder/ Testicles N(%)	Auricle N(%)	Anus/Tail N(%)	Legs N(%)	Others N(%)
A. variegatum	109	4(3.67)^{e}	35(32.11)^{g}	20(18.34)^{g}	11(10.09)^{d}	13(11.92)^{f}	54(49.54)^{h}	16(14.67)^{e}
R. microplus	20	1(5.5)^{b}	4(22.22)^{d}	3(16.66)^{d}	5(27.77)^{b}	0(0)^{a}	4(22.22)^{c}	1(5.5)^{b}
R. decoloratus	48	4(8.3)^{e}	5(10.41)^{e}	3(6.25)^{d}	23(47.91)^{f}	0(0)^{a}	20(41.66)^{g}	3(6.25)^{d}
R. geigyi	34	1(2.94)^{b}	0(0)^{a}	6(17.64)^{f}	14(41.17)^{e}	1(2.94)^{b}	6(17.64)^{d}	3(8.8)^{d}
R. annulatus	23	2(10.00)^{c}	1(4.34)^{b}	0(0)^{a}	8(23.52)^{c}	0(0)^{a}	12(35.29)^{e}	1(4.34)^{b}
R. muhsamae	31	2(6.45)^{c}	8(25.8)^{f}	4(12.9)^{e}	0(0)^{a}	4(12.9)^{c}	12(38.7)^{e}	2(6.45)^{c}
R. lunulatus	20	0(0)^{a}	5(25)^{e}	4(20)^{e}	0(0)^{a}	0(0)^{a}	15(75)^{f}	0(0)^{a}
R. guilhoni	61	0(0)^{a}	3(4.91)^{c}	2(3.27)^{c}	55(90.16)^{h}	7(11.47)^{d}	0(0)^{a}	0(0)^{a}
R. evertsi	49	2(4.08)^{c}	1(2.04)^{b}	0(0)^{a}	41(83.67)^{g}	9(18.36)^{e}	2(4.08)^{b}	3(6.12)^{d}
R. sanguineus	22	0(0)^{a}	0(0)^{a}	1(4.54)^{b}	8(36.36)^{c}	13(59.09)^{f}	0(0)^{a}	0(0)^{a}
I. pilosus	68	3(4.41)^{d}	0(0)^{a}	2(3.27)^{c}	8(13.11)^{c}	1(1.6)^{b}	57(86.36)^{i}	1(1.6)^{b}
H. punctate	1	0(0)^{a}	0(0)^{a}	1(100)^{b}	0(0)^{a}	0(0)^{a}	0(0)^{a}	0(0)^{a}
R. sinus	1	0(0)^{a}	0(0)^{a}	1(100)^{b}	0(0)^{a}	0(0)^{a}	0(0)^{a}	0(0)^{a}
Overall frequency	306	11(3.59)	49(16)	38(12.41)	121(39.54)	42(13.72)	90(29.41)	26(8.49)

N = number of infested animals, values in parenthesis = percentages, Others = the back, the eyes and neck, $^{a-h}$ = values with different letter superscripts along a column are significantly different ($p<0.05$)

Concerning *A. variegatum,* it is the most common species in this study. A comparable situation has been observed by Kouam and Dongmo (2018). This species infested sheep all the year with its frequency higher in rainy (in April) than in the dry season. This finding is consistent with previous studies (Chartier *et al.,* 2000; Farougou *et al*., 2007). It is known to be a ubiquitous parasite in sub-Saharan Africa (Farougou *et al*., 2007) and transmits *Theileria separta* which causes benign theileriosis in small ruminants.

This study reports the presence of the invasive tick species *R. microplus* on sheep in the Bamboutos Division. This tick species infests sheep in the rainy and dry seasons. This shows the progressive establishment of this species locally. It is the result of the rapid spread of this tick during cattle transhumance movements. This tick passed from cattle to sheep in the Bamboutos Division in mixed grazing areas. *R. b. microplus* is the most important ectoparasite and disease vector of livestock globally. It is also involved in the transmission of pathogens usually harboured by native tick species (Walker and Olwage, 1987).

The distribution of certain species was different according to altitude. Indeed, *R. guilhoni* and *R. sanguineus* were most frequent and abundant in high-altitude areas, while *I. pilosus* and *A. variegatum* were most frequent and abundant in low-altitude areas. This may be because temperature, humidity and vegetation are different between those facies. Moreover, McCoy *et al.* (2013) demonstrated that the presence, development and distribution of ticks in an ecosystem are dependent on various conditions including climate.

In general, tick infestations were more frequent during the rainy season than during the dry season. This finding is consistent with previous studies which state that tick parasitism is reduced during the dry months (Lontsi-Demano *et al.,* 2020). This may be because temperature and humidity are most favourable during the rainy season for the development and survival of ticks in the pasture. The genus *Amblyomma* and the subgenus *Boophilus* infested sheep during the rainy and dry season while the genus *Rhipicephalus* infested sheep only during the rainy season and the genus *Ixodes* only in the dry season. This observation is intrinsically associated with tick biology and environmental conditions. It has been demonstrated that *Amblyomma* and *Boophilus* genera are present in the pasture all the year but with a frequency higher in the rainy season than in the dry season (Chartier *et al.,* 2000; Lontsi-Demano *et al.,* 2020), while the genus *Rhipicephalus* is associated with the warm and humid condition (Ayalew *et al.,* 2014). On the other hand, according to Walker *et al.* (2003), the adults of the *Ixodes* genus are present on their host mainly during autumn and summer which corresponds to the dry season of this study.

Adult sheep were most infested and had a higher mean tick count than juveniles and lambs. These results agree with previous reports (Malla *et al*., 2021). This could be because adults have passed more times and are more in movement in the pasture than the other; this increases the likelihood of contact with questing ticks. Moreover, adults have a larger body surface area, giving ticks more room.

A small proportion of infested sheep (14.7%) presented dermatophilosis. This could be favoured by the presence of *A. variegatum.* Indeed, according to Stachurski *et al.* (2010), this tick has been associated with dermatophilosis caused by the bacterium *Dermatophilus congolensis.*

The different tick species prefer to attach and feed on specific parts of the body of animals. *Amblyomma* ticks were mostly found on the legs, the abdomen and the udder/testicles. *Ixodes* ticks were mostly found on the legs, while *Rhipicephalus* ticks were mostly found on the auricle, the anus/tail and the legs. These findings are consistent with previous reports (Keita, 2007; Sado Yousseu *et al.,* 2022). In general, ticks are mostly found in parts of the body that have little or no hair and that are in contact with vegetation (Keita, 2007). The principal limitation of this study is the lack of molecular identification due to the scarcity of specialized laboratories in the country.

Conclusion: Mixed grazing sheep and cattle favour the installation of cattle tick species in sheep. Many tick species hinder the development of sheep in the Bamboutos Division and their distribution varies according to altitude and season. *R. guilhoni, R. b. decoloratus and A. variegatum* were found to be the most abundant tick species. Farmers must be made aware of the importance of tick control to reduce or avoid losses due to ticks.

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