Article

Species composition, diversity and predilection sites of ticks (Acari: Ixodidae) infesting cattle in the Western Highlands of Cameroon

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Abstract

Ticks are haematophagous ectoparasites infesting wilds and domestic animals as well as humans and, are considered after mosquitoes to be the principal vectors for the transmission of various pathogens. The ixodid tick fauna remains poorly understood and the aim of the present study was to determine their species composition, species diversity and predilection sites as well as their relative frequency, infestation abundance and intensity of infestation amongst cattle in the Western Highlands of Cameroon. In present study, a total of 2348 ticks were collected both on 182 cattle and vegetation and identified at species level using a valid identification keys. Three life stages: adults (91.52%), nymphs (5.88%) and larvae (2.6%), four genera: *Amblyomma* (50.8%), *Rhipicephalus* (35.44%), *Hyalomma* (0.46%) and *Haemaphysalis* (5.24%) and nine species of ticks: *Amblyomma variegatum* (42.42%), *Rhipicephalus (B) decoloratus* (17.97%), *Rhipicephalus (B) microplus* (13.67%), *Amblyomma hebraeum* (8.4%), *Hyalomma rufipes* (8.05%), *Haemaphysalis leachi* (5.24%), *Rhipicephalus sanguineus* (2.47%), *Rhipicephalus (B) annulatus* (1.32%) and *Hyalomma truncatum* (0.46%) were found. The overall prevalence of infestation was 78.57%. Cattle with the poor body condition score (57.34%) were the most infested while the most infested sites of attachment were perineum (37.64%), followed by the head (23.14%), the ventral side (19.15%), the neck (11.8%), the back (5.84%) and the legs (2.43%). The infestation abundance was assessed to 10.15 ticks per cattle. The high parasitic load was found on perineum (4.86) as well as *Amblyomma variegatum* (4.87) was the species with the high intensity burden. Species diversity was assessed using species indices. *Amblyomma variegatum* was identified as eudominant species with the most relative abundance. According to SHE analysis, it appeared that evenness had an effect on the changes of species diversity and also, it showed that cattle and vegetation are occupied by common species. This result will permit to improve the knowledge on the species composition, species diversity and predilection sites of ticks present in the study area and may also help to build up a good controlstrategy for ticks as well as associated diseases.

Keywords Ixodidae; Acari; ticks, predilection sites;species composition; diversity; prevalence; Western Highlands; Cameroon.

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1 Introduction

Ticks and diseases transmitted are major constraints to livestock improvement in many parts of the world especially in the tropical and sub-tropical countries. They are obligate blood-feeding ectoparasites of vertebrates particularly mammals and birds belonging to the Phylum Arthropoda and make up the largest collection of species in the order Acarina (Mohammed and Hassan, 2007). They are divided into two major groups; soft-bodied ticks (Argasidae) and hard-bodied species (Ixodidae) (Liyanaarachchi et al., 2013) and their distribution has changed, due to extensive animal movement, deforestation and desertification (Moges et al., 2012; Estrada-Peña and Salman, 2013).

Ticks are responsible for reduction of body weight, blood loss, morbidity and mortality caused by the disease transmitted to cattle which also affects milk and meat production. Furthermore, bites reduce the quality of leather (Gholam et al., 2007; Domingos et al., 2013). Several ticks' species are widely distributed throughout the world particularly in tropical and sub-tropical countries with more than 60 species known to exist in East Africa alone **(**Moges et al., 2012). It has been estimated that 80% of the world's cattle are infested with ticks (Minjauw et al., 1997) and the production of over 1000 million cattle around the world are affected (Estrada-Peña and Salman, 2013).

In Cameroon, livestock play an important role in agriculture contributing about 9% of the total agricultural or about 2.1% of the Gross Domestic Product (MINEPIA, 2012). In Cameroon, human population is expected to grow by more than 50% by the year 2050 and the challenge for livestock enterprise is to produce food for the growing population using no extra land. To meet up with the consumption rate, it requires developing a viable livestock industry, good management disease control and production methods to harness the potentials of animal endowments. In 1960, Cameroon had about 1,750 heads of horned cattle. By 1983/1984, the number was 4,040 heads, about 4.6 million cows in 1995, 5.6 million in 2003 and, it had increased to about 5.9 million in 2007 (MINEPIA, 2012; Ngalim, 2015), the Western Highlands being the third major cattle producing area of the country. However, these cattle are on the menace of some vector transmitting diseases such as Tsetse fly, the main vector of bovine trypanosomiasis and, Boophilids (Ixodid ticks) which transmit piroplasmosis and anaplasmosis in cattle (Ndi et al., 1991).

The Western Highlands of Cameroon have a special climate and abundant superficial water resources favourable for agriculture and animal husbandry, which are the main characteristics for the proliferation of ticks and of course TBDs (Pingpoh et al., 2007). Relatively little information is available on ticks infesting cattle and their role as disease vectors in the study area where, cattle production is predominantly based on traditional production system involving mainly rural population.

This work had drawn attention to ticks as sources of potential significant losses to livestock production through direct damage caused by feeding activity (infestation) as well as the establishment of an appropriate control strategy.

2 Material and Methods

2.1 Study area

The Region considered as the Western Highlands is the third Agro-Ecological Zone (AEZ) of Cameroon (IRAD, 2008). It comprises two Administrative Regions (West and North-West), due to their common biotic and abiotic characteristics. It lies between latitudes 5° and 7° North and longitude 9° and 11° East of the Equator. With a size of 31,180 km^2, they cover 1/16 of the total land area of the country. Altitudes range from around 300 to 3 000 m above sea level. The climate of this region is the tropical humid type with two seasons, the dry and rainy seasons. Rainfall varies between 1300-3000 mm with peaks occurring between mid-July and mid-September. The rainy season extends from mid-March to mid-November while the dry season runs from end of mid-November to mid-March. The maximum temperatures vary between 20 and 32°C. The dominant vegetation is residual savannah and the region is designated grassland because a greater proportion of the area is covered by grassland than forest. The relief is mountainous with many plains and plateaus, the soils are ferralitic, of volcanic origin and rather fertile although soil pH is on the low side. In this region is found the Bambouto Mountains 2700 m and the Oku Mountain 3011 m considered as the second highest mountain in Cameroon. This Region is characterized by a rapid population growth (128.5 inhabitants per km^2), most of whom live in rural areas (67.8%) and depend on crop and livestock activities (IRAD, 2008; Nchinda and Mendi, 2008; Jiotsa et al., 2016).

2.2 Study population

Cattle in and around the Western Highlands of Cameroon were the target population for the purpose study. The area is the third major cattle producing area in the country with, the livestock population estimated to 500,000 (about 17% of the Cameroonian cattle herd) Zebu cattle (IRAD, 2008; MINEPIA, 2012).

2.3 Sample collection

Body parts of cattle known as predilection sites were firstly established and divided into six parts (Fig. 1), so that, ticks recovered from each animal were collectedusing the hand picking methods (Fig. 2). They were also collected from vegetation using a flag dragging technique (Fig. 3) and, all the specimen was placed in separate bottles containing 70% ethyl alcohol. Bottles was labelled including date, locality and sites of attachment.

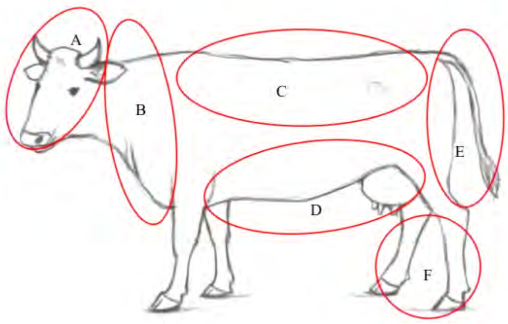

Fig. 1 Established predilection sites of ticks on cattle. A= Head (ears, eyes); B= Neck (neck, chess, dewlap); C= Back (dorsal side); D= Ventral side (belly, scrotum/udder, lateral side); E= Perineum (tail, anus); F= Legs (legs, hoof).

Fig. 2 Hand picking of ticks on the belly of cattle.

Fig. 3 Collection of ticke on vegetation using a flag.

Fig. 4 Bottles containing ticks collected from cattle and vegetation.

2.4 Statistical analysis

All raw data were uploaded into Microsoft Excel 2016 computer program, then analysed by Statistical Package for Social Sciences Version 23 (IBM SPSS Statics 23, USA) software and summarized by using tables. Chi-square test was used to compare the prevalence of tick infestation, relative frequency, abundance and intensity of infestationbetween recorded variables. A *P*-value of 0.05 or less was considered significant.

3 Results

The prevalence was calculated as percent of infested animals from the total number of animals examined. Then, ixodid ticks of cattle were found highly prevalent in the study area with overall prevalence of 78.57%. Female cattle (82.85%) were more infested than male (72.72%) but without significant difference (Table 1).

Table 1 Prevalence of infestation of ticks on cattle.

	Cattle sampled	Infested		Confidence interval
		No	(%)	
Male	77	56	72.72	54.94 ± 94.44
Female	105	87	82.85	66.37 ± 102.2
Total	182	143	78.57	66.22 ± 92.56

$\chi^2 = 6.294$; $df = 1$; $P = 0.1021$

The body condition of cattle was also assessed and classified as Poor, Moderate or Good according to the healthy appearance of their fur, colour and hair length. It appeared that cattle having a poor body condition score were the most infested with a prevalence of 57.34%, followed by those having moderate (28.67%) and good condition (13.99%). A significant difference was observed between the three body condition of cattle (Table 2).

Table 2 Prevalence of infestation according to body codition score.

Body condition	Examined			Infested					
	Male	Female	Total	Male		Female		Total	
				No	%	No	%	No	%
Poor	34	59	93	29	85.29	53	89.83	82	88.97
Moderate	23	34	57	16	69.56	25	73.52	41	79.9
Good	20	12	32	11	55	9	75	20	62.5

χ^2 = 1.72; *df* = 2; *P* < 0.001

An epidemiological indicator such as the relative frequency or relative abundanceof each tick species was estimated in order to appreciate their abundance in the study area. It was calculated as a percent of tick belonging to a given species from total number of collected ticks. Out of the 2348 ticks sampled in the study area, three life stages (larva, nymphs and adults), four different genera (*Amblyomma* sp, *Rhipicephalus* sp, *Hyalomma* sp and *Haemaphysalis* sp) and nine species namely *Amblyomma variegatum* (42.42%), *Rhipicephalus (B) decoloratus* (17.97%), *Rhipicephalus (B) microplus* (13.67%), *Amblyomma hebraeum* (8.4%), *Hyalomma rufipes* (8.05%), *Haemaphysalis leachi* (5.24%), *Rhipicephalus sanguineus* (2.47%), *Rhipicephalus (B) annulatus* (1.32%) and *Hyalomma truncatum* (0.46%) were identified.Also, to evaluate the dominance structure of ticks, we used a classification made by Heydemann. This classification is made up of five levels of dominance such as: eudominant species (more than 30% of all the ticks collected), dominant (10-30%), subdominant (5-10%), rare (1-5%) and subrare (less than 1%) and it appeared that *Amblyomma variegatum* was identified as eudominant species with the most abundanceboth on cattle and vegetation as well as in the study area (Table 3).

Table 3 Number of specimen collected, abundance and dominance structure of ixodid ticks in the study area.

Species found	Cattle			Vegetation			Total area		
	No	Relative abundance (%)	Dominance structure	No	Relative abundance (%)	Dominance structure	No	Relative abundance (%)	Dominance structure
	χ^2= 1766.912; *df* = 8; *P* < 0.0001			χ^2= 1149.016; *df* =8; *P* < 0.0001			χ^2= 2892.721; *df* = 8; *P* < 0.0001		
Amblyomma variegatum	697	37.7	Eudominant	299	59.2	Eudominant	996	42.42	Eudominant
Amblyomma hebraeum	176	9.52	Subdominant	21	4.21	Rare	197	8.4	Subdominant
Rhipicephalus (B) decoloratus	339	18.33	Dominant	83	16.66	Dominant	422	17.97	Dominant
Rhipicephalus (B) microplus	244	13.2	Dominant	77	15.43	Dominant	321	13.67	Dominant
Rhipicephalus sanguineus	51	2.76	Rare	7	1.41	Rare	58	2.47	Rare
Rhipicephalus (B) annulatus	31	1.68	Rare	0	0	Subrare	31	1.32	Rare
Hyalomma rufipes	187	10.11	Dominant	2	0.4	Subrare	189	8.05	Subdominant
Hyalomma truncatum	10	0.54	Subrare	1	0.2	Subrare	11	0.46	Subrare
Haemaphysalis leachi	114	6.66	Subdominant	9	1.8	Rare	123	5.24	Subdominant
Total	1849	100		499	100		2348	100	

According to the life stage, we found that adults' tick (91.52%) was the most abundant followed by the nymphs (5.88%) and larva (2.6%) in the study area as well as on cattle and vegetation.Likewise, *Amblyomma variegatum* was the tick's species having a higher relative abundance on each life stages, followed by *Rhipicephalus (B) decoloratus* and *Rhipicephalus (B) microplus*. However, the larva of *Amblyomma hebraeum*, *Rhipicephalus sanguineus*, *Rhipicephalus (B) annulatus*, *Hyalomma rufipes*, *Hyalomma truncatum*and *Haemaphysalis leachi* were not found as well as nymphs of *Rhipicephalus (B) annulatus* and *Hyalomma truncatum* (Table 4). Furthermore, there were more larvae on the perineum (0.15%) and head (0.14%), more nymphs on the head (0.27%) while adults dominated on the perineum (4.47%), with the relative abundance of all these three life stages significantly different. Adults ticks were collected on all the body part of cattle while larvae and nymphs were practically absent on the back and legs (Table 5).

Table 4 Relative abundance according to life stage in the study area.

	Sampled sites					
	Cattle		Vegetation		Study area	
Life stages	No	%	No	%	No	%
Larvae	55	2.98	6	1.20	61	2.6
Nymphs	112	6.06	26	5.21	138	5.88
Adults	1682	90.96	467	93.59	2149	91.52
Total	1849	100	499	100	2348	100
	Life stages					
Ticks' species	Larvae		Nymphs		Adults	
	No	%	No	%	No	%
Amblyomma variegatum	26	42.63	68	49.28	902	42
Amblyomma hebraeum			2	1.45	195	9.07
Rhipicephalus (B) decoloratus	32	52.46	27	19.56	363	16.89
Rhipicephalus (B) microplus	3	4.91	27	19.56	291	13.54
Rhipicephalus sanguineus			4	2.9	54	2.51
Rhipicephalus (B) annulatus					31	1.44
Hyalomma rufipes			1	0.72	188	8.74
Hyalomma truncatum					11	0.51
Haemaphysalis leachi			9	6.53	114	5.3
Total	61	100	138	100	2149	100

Table 5 An overview of tick life stage placement on different attachment sites.

	Head	Neck	Back	Ventral side	Perineum	Legs	Total
Larvae	20	5	0	8	22	0	55
Nymphs	39	13	0	26	34	0	112
Adults	369	200	108	320	640	45	1682
Larvae (%)	0.14	0.03	0	0.05	0.15	0	2.6
Nymphs (%)	0.27	0.09	0	0.18	0.23	0	5.87
Adults (%)	2.58	1.4	0.75	2.23	4.47	0.31	91.53

$\chi^2 = 2766.511$, $P < 0.0001$

Table 6 indicates the distribution of ticks over predilection sites on cattle under study. The survey clearly indicated that every tick species prefers different site. It appeared that the perineum (37.64%) was the most preferred site, followed by the head (23.14%), the ventral side (19.15%), the neck (11.8%), the back (5.84%) and lastly the legs (2.43%). Except the legs where *Rhipicephalus (B) microplus* was the most abundant species, *Amblyomma variegatum* was the species most abundant on the five other predilection sites and even on vegetation. However, let's note that each tick species had its preferred or predilection sites.

Table 6 Distribution of ticks over predilection sites on cattle sampled in the study area.

	Amblyomma variegatum	*Amblyomma hebraeum*	*Rhipichephalus (B) decoloratus*	*Rhipichephalus (B) microplus*	*Rhipichephalus (B) sanguinus*	*Rhipichephalus (B) annulatus*	*Hyalomma rufipes*	*Hyalomma truncatum*	*Haemaphysalis leachi*	Total	
Cattle										No	%
Head	157	61	90	49	16	1	31	0	23	428	23.14
Neck	84	26	32	21	11	6	27	0	11	218	11.8
Back	29	7	18	13	0	4	17	2	18	108	5.84
Ventral side	154	14	46	41	15	13	43	4	24	354	19.15
Perineum	262	68	146	104	9	7	64	4	32	696	37.64
Legs	11	0	7	16	0	0	5	0	6	45	2.43
∑	697	176	339	244	51	31	187	10	114	1849	100
Relative abundance	37.7	9.52	18.33	13.2	2.76	1.68	10.11	0.54	6,16	100	
Vegetation	59.2	4.21	16.63	15.43	1.41	0	0.4	0.2	1.8	100	

The total number of all the ticks collected was estimated in the term of infestation abundance, that is the mean number of tick per cattle on the study area helping to appreciate the distribution of this ectoparasite in the study area. Then, it has been calculated as the ratio of the number of tick collected by the total population of cattle examined and found that 10.15 was the mean abundance of ticks per cattle in the study area.

The intensity of infestation or tick burden was also considered as an epidemiological indicator and therefore was evaluated as the number of ticks per site of fixation on infested cattle. The mean burden of ticks was assessed to 12.93 ticks per infested cattle in the study area. Based on the predilection sites, it was found gradually 4.86 ticks/cattle on perineum,3 ticks/cattle on head, 2.48 ticks/cattle onventral side, 1.52 ticks/cattle on neck, 0.76 ticks/cattle on back and 0.31 ticks/cattle on legs (Table 7). Specifically, *Amblyomma variegatum* was the species with a higher intensity load (4.87/cattle) followed by *Rhipicephalus (B) decoloratus* (2.37/cattle), *Rhipicephalus (B) microplus* (1.7/cattle), *Hyalomma rufipes* (1.3/cattle), *Amblyomma hebraeum* (1.23/cattle), *Haemaphysalis leachi* (0.79/cattle), *Rhipicephalus sanguineus* (0.35/cattle), *Rhipicephalus (B) annulatus* (0.21/cattle) and *Hyalomma truncatum* (0.06/cattle). Therefore, there was a significant difference in the intensity of infestation of the nine tick species and even of the six predilection sites.

It was found in the study area that, the values for Simpson's indices of dominance weighted towards the abundance of the commonest species *Amblyomma variegatum* (0.17), *Rhipicephalus (B) decoloratus* (0.03) and *Rhipicephalus (B) microplus* (0.01). The Shannon-Weaver diversity and Simpson's dominance indices computed for the cattle, vegetation and study area are shown in Table 8.

Table 7 Intensity of infestation of ticks on cattle of the study area.

Ticks' species	No. specimen collected	Intensity of infestation	Confidence interval
	χ^2 = 1770.684; *df* = 8; *P* < 0.0001		
Amblyomma variegatum	697	4.87	4.51 ± 5.24
Amblyomma hebraeum	176	1.23	1.05 ± 1.42
Rhipicephalus (B) decoloratus	339	2.37	2.12 ± 2.63
Rhipicephalus (B) microplus	244	1.7	1.49 ± 1.93
Rhipicephalus sanguineus	51	0.35	0.26 ± 0.46
Rhipicephalus (B) annulatus	31	0.21	0.14 ± 0.30
Hyalomma rufipes	187	1.3	1.12 ± 1.50
Hyalomma truncatum	10	0.06	0.03 ± 0.12
Haemaphysalis leachi	114	0.79	0.65 ± 0.95
Total	1849	12.93	12.34 ± 13.53

	Head	Neck	Back	Ventral side	Perineum	Legs	Total
Predilection sites		χ^2 = 922.646; *df* = 5; *P* < 0.0001					
	3	1.52	0.76	2.48	4.86	0.31	12.93

Table 8 Diversity of ticks' species recovered cattle and vegetation in the study area.

Species (S=9)	Cattle		Vegetation		Study area	
	Simpson (D_s)	Shannon (H)	Simpson (D_s)	Shannon (H)	Simpson (D_s)	Shannon (H)
Amblyomma variegatum	0.14	0.36	0.35	0.30	0.17	0.36
Amblyomma hebraeum	0.01	0.21	0	0.12	0	0.20
Rhipicephalus (B) decoloratus	0.03	0.30	0.02	0.29	0.03	0.30
Rhipicephalus (B) microplus	0.01	0.26	0.02	0.28	0.01	0.26
Rhipicephalus sanguineus	0	0.07	0	0.04	0	0.07
Rhipicephalus (B) annulatus	0	0.04	0		0	0.04
Hyalomma rufipes	0.01	0.23	0		0	0.20
Hyalomma truncatum	0		0		0	
Haemaphysalis leachi	0	0.16	0	0.04	0	0.14

The highest values of Shannon (H = 1.63) and richness indices (D_{Mg}=1.12; D_{Mn}= 0.35) was observed respectively on cattle and vegetation. The highest values of dominance (D_s = 0.41; d = 0.51) were observed on vegetation. Evenness indices showed the maximum values on cattle (E = 0.74; 1-Ds = 0.79). Richness corrected estimator and species richness had not changed.According to preferred sites of attachment, the highest values of Shannon (H = 1.86) and richness indices (D_{Mg}=0.49; D_{Mn}= 0.76) was observed in the back. The highest values of dominance (D_s = 0.24; d = 0.43) were observed in the ventral side.The maximum values of evenness indices (E = 0.93; 1-Ds = 0.84) was showed respectively in the legs and the back. Richness corrected estimator and species richness had not changed for the whole predilection sites (Table 9).

Table 9 Diversity and species richness of ticks caught on cattle and vegetation.

According to sample site			
	Cattle	Vegetation	Study area
Chao estimator	9	8	9
Species richness (S)	9	8	9
Fisher Alpha	18.67	5.04	23.71
Simpson (Ds)	0.21	0.41	0.24
Simpson (1-Ds)	0.79	0.59	0.76
Berger-Parker (d)	0.37	0.59	0.42
Shannon-Weaver (H)	1.63	1.07	1.57
Evenness (E)	0.74	0.51	0.71
Margalef (D_{Mg})	1.06	1.12	1.03
Menhinick (D_{Mn})	0.20	0.35	0.18
Mc Intosh (D)	0.54	0.37	0.51

According to predilection sites						
	Head	Neck	Back	Ventral side	Perineum	Legs
Chao estimator	8	8	8	9	9	5
Species richness (S)	8	8	8	9	9	5
Fisher Alpha	4.32	2.20	12	3.57	7.03	5
Simpson (Ds)	0.21	0.21	0.16	0.24	0.22	0.23
Simpson (1-Ds)	0.79	0.79	0.84	0.76	0.78	0.77
Berger-Parker (d)	0.36	0.38	0.26	0.43	0.37	0.35
Shannon-Weaver (H)	1.71	1.78	1.86	1.74	1.69	1.51
Evenness (E)	0.82	0.84	0.89	0.79	0.76	0.93
Margalef (D_{Mg})	1.15	1.30	1.49	1.36	1.22	1.05
Menhinick (D_{Mn})	0.38	0.54	0.76	0.47	0.34	0.74
Mc Intosh (D)	0.55	0.57	0.68	0.53	0.54	0.59

SHE analysis resolves biodiversity into three components: species richness S (as lnS), Shannon index H and evenness E (as lnE) and were calculatedcumulatively (Table 9). The SHE analysis on the predilection sites showed that the biggest values of richness (lnS = 2.19) was observed in the ventral side and perineum while the biggest diversity (H = 1.86) was found in the back. Between the sample sites of ticks, the biggest values of richness (lnS = 2.19) and diversity (H = 1.63) were observed in cattle. In addition, greater evenness (lnE = -

0.07) and (lnE = -0.24) were observed in the legs and vegetation respectively (Table 10).

Table 10 Results of SHE analysis data in different preferred and sample sites.

	N	lnN	lnS	H	lnE	lnE/lnS
Head	428	6.05	2.07	1.71	-0.19	-0.09
Neck	218	5.38	2.07	1.78	-0.17	-0.08
Back	108	4.68	2.07	1.86	-0.11	-0.05
Ventral side	354	5.86	2.19	1.74	-0.23	-0.10
Perineum	696	6.54	2.19	1.69	-0.27	-0.12
Legs	45	3.80	1.6	1.50	-0.07	-0.04
Cattle	1849	7.52	2.19	1.63	-0.74	-0.34
Vegetation	499	6.21	2.07	1.07	-0.51	-0.24
Total	2348	7.76	2.19	1.57	-0.71	-0.32

4 Discussion

The prevalence of infestation of ticks in the Western Highlands of Cameroon assessed to 78.57% and therefore similarto those obtained in Ethiopia by Kemal et al. (2016) and Abdella et al. (2017) as well as, it was highercompared to those obtained in Ethiopia by Admassu et al. (2014), Fesseha and Mathewos (2020), in Indonesia by Dwinata et al. (2020) or in Pakistan by Hussain et al. (2021). It was also low than those found by Tadesse and Uro (2019), Nasero and Roba (2020) and Ayana et al. (2021) in Ethiopia. According to Geduliet al. (2016), the high prevalence of tick infestation in the study area might be associated to the lack of community awareness about the impact of ticks, health care services and management practices on livestock production. This result has permitted to conclude that the control strategy of ticks and animal hygiene would not be well implemented in the study area, leading to the heavy prevalence of infestation of ticks as well as the high infection rate of tick-borne diseases in cattle.

The body condition scores were assessed to well understand the distribution of ticks on cattle. It appeared that, cattle with the poor body condition (57.34%) were most infested than those with moderate (28.67%) and good condition (13.99%). This observation was comparable with the finding of Aliye and Anwar (2020), Nasero and Roba (2020) and Fesseha and Mathewos (2020). The preference of ticks to infest cattle with the poor body condition seems to be due to the poor quality of their skin hygiene and even the lack of enough body capacity to build resistance. Moreover, a highest tick burden might be a cause of this poor body condition. The study revealed the widespread occurrence of ticks' infestation in cattle of the study area.

According to Walker et al., (2003), ticks which are considered to be most important to health of domestic animal in Africa comprise about seven genera and, four of them were identified in our study. The most abundant genus was *Ambylomma* sp (50.8%) followed by *Rhipicephalus* sp (35.44%) and *Haemaphysalis* sp (8.52%) while *Hyalomma* sp (5.24%) was the less abundant.Similar results were obtained by Tadesse et al. (2012), Admassu et al. (2015), Ikpeze et al. (2015), Kemal et al. (2016) and Tadesse and Uro (2019). Excepted that they did not identified the *Haemaphysalis* genus with, they found that *Ambylomma* sp and *Hyalomma* sp were respectively the most and the less abundant. Furthermore, these finding were different from those of

Adelabu et al. (2020) and Aliye and Anwar (2020), where they found *Rhipicephalus* sp and *Haemaphysalis* sp respectively the most and the less abundant while, Elias et al. (2020) and Ayana et al. (2021) reported that *Rhipicephalus* sp was most abundant than *Hyalomma* sp. Likewise, Fatemian et al. (2018), Ahmad et al. (2019) and Fesseha and Mathewos (2020) reports stated that *Hyalomma* genus was most abundant while *Rhipicephalus* sp was the less. *Amblyomma variegatum* (42.42%) was the eudominant and the most abundant tick species identified in the Western Highlands of Cameroon while *Hyalomma truncatum* (0.46%) was the least recorded.This was comparable with the finding of Silatsa et al. (2019) in Cameroon where, they identified more than thirteen ticks'species with an apparently displacement of the indigenous *Rhipicephalus (B) decoloratus* by *Rhipicephalus (B) microplus.*The percentage of abundance of the eudominant species was in accordance with that of finding of Admassu et al. (2015), Mollong et al. (2018), Tadesse and Uro (2019) but, lower according to the one of Ikpeze et al. (2015) and may due to land exploitation, climate change or host ecology. The higher relative abundance of ticks found in the Western Highlands of Cameroon calls for an urgent response through the planning of a good control strategies and consequently the safeguard of the livestock production and even the health status of cattle and farmers.

According to the life stages, we found that adults tick (91.52%) was the most recorded followed by the nymphs (5.88%) and larvae (2.6%). The result of this study is comparable with tick survey conducted in Europe by Mysterud et al. (2014). The low relative frequency of the larval and nymphal stages might be due to the time of collection which was mostly during dry season, the time where cattle were in transhumance and then let the grazing area free of ticks. We also provided insight on how different stages of ticks select different body part for attachment on cattle in the Western Highlands of Cameroon. The preferred site selection reflected the life stages differing ability to move or hide. The larvae and nymphs were mainly found on perineum and head with a short distance to move after encountering the host while adult ticks were mainly found on perineum with the ability to hide longer.

The body of cattle was divided into six parts. Except the legs, *Amblyomma variegatum* was the species most found on thefive other body parts of cattle in this study, finding comparable with those of Ikpeze et al. (2011). In these location, it would be very difficult for the host to dislodge the ticks.Occupation of the different preferred sites by ticks may involve complex intrinsic behaviours that are under chemical control. Robert and Janovy (2000) cited by Ikpeze et al. (2011) had explained that different pheromones which emanate from the anus, coxalglandsn and female genital aperture of female ticks control other behaviours such as aggregation, searching and aggregation, clasping and attachment during mating, attraction and potential mate recognition in males, mounting and copulation. It was observed that most of the male and female adult of *Amblyomma variegatum* recovered during the study were aggregated in clusters.Let's note thatperineum (37.64%) was the most infested body partof cattle followed by head (23.14%), ventral side (19.15%), neck (11.8%), back (5.84%) and legs (2.43%). The finding was in agreement with the reports of Tadesse et al. (2012), Ikpeze et al. (2015), Belpena et al. (2020) and Dwinata et al. (2020) who found that the most infested body parts of the cattle were udder/scrotum, the equivalent of perineum in our study but, different from those of Admassu et al. (2015) and Nasero and Roba (2020)where they found respectively ventral side and neck as the most infested sites. Then, the preference of ticks to attach on the perineum, the head and the ventral side, considered as their predilection sites could be due by the fact that, ticks easily access these sites while questing on tall grasses and vegetation, as cattle pass by. Likewise, these sites might be less accessible and therefore considered as a hiding place for them against birds and human control or also the difference between the establishment of the body part of cattle in each survey.

Infestation abundance was assessed to 10.1 ticks per cattle and higher compared to those obtained by Ikpeze et al. (2015), Elati et al. (2018) and Moubamba et al. (2020) who respectively found 2.87, 3.7 and 0.007

ticks/cattle. These results should help cattle owners to improve animal hygiene and veterinarians to implement efficient control programs against ticks and the transmitted pathogens in the study area.

Perineum was the body part having the highest infestation burden (4.86 ticks/cattle) and legs the site of attachment having the lowest (0.31 ticks/cattle). The mean intensity of infestation of the whole infested cattlein the study areawas assessed to 12.93 ticks/cattle. This result was corroborated by the finding of Kerario et al. (2017) but, was highest according to the 2.7 ticks/cattle found in Gabon by Moubamba et al. (2020) and lower according to the 25.8 ticks/cattle observed in United Arab Emirates by Al-Deeb and Muzaffar (2020). Poor body condition resulting to the non-respect of animal hygiene could be the main raison of this results. The specific intensity of infestation of ticks of an infected cattle in the study area was assessed and we found that the species with the high intensity load was *Amblyomma variegatum* (4.87 ticks/cattle) while *Hyalomma truncatum* (0.06 ticks/cattle) had the lowest one. This finding was not in agreement with the reports of Yessinou et al. (2018) who found instead *Rhipicephalus microplus* and *Hyalomma* sp as a ticks' species having respectively higher (126.23 ticks/cattle) and lower (3.25 ticks/cattle) intensity burden. These results could be exploited to include genetic and non-genetic approaches to tick control.

Simpson's dominant indices indicated that *Amblyomma variegatum* was the dominant species. The highest diversity was observed in cattle while highest richness was observed in vegetation. Usually, diversity is positively related to species richness. So, higher levels of richness in the study area means that the highest diversity was observed. It should be noted that, although higher richness was observed on vegetation and higher diversity on cattle, richness, evenness or dominance could have an effect on diversity. In this case, greater dominance and less evenness on vegetation than cattle caused that the amount of diversity decreased. So, diversity was more affected by evenness or dominance than richness (Fazeli-Dinan et al., 2019).

The SHE analysis on cattle, vegetation and predilection sites indicated that the diversity is not sensitive to evenness and, the fluctuations of diversity components (H, lnS, lnE and lnE/lnS) confirmed that tick distribution did not follow any particular pattern and so, species are relatively common (Small and McCarthy, 2002 and Murray, 2003 cited by Fazeli-Dinan et al., 2019).

Accordingly, the study showed that the higher prevalence of ticks is still playing a major role in reducing productivity and cause health problems amongst cattle in the area which needs a serious collaborative effort and urgent attention. Therefore, sustainable tick control measures should be put in place in order to reduce the current trend of prevalence to lower level and consequently improve the livestock production in terms of quantity and quality.

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