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Cattle trading favors the introduction and establishment of the invasive tick *Rhipicephalus* (*Boophilus*) *microplus* in Menoua Division, West Region of Cameroon

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Abstract
Tick infestation is a major public health and veterinary issue that limits animal productivity throughout the world. Uncontrolled cattle movements during trading creates risks for introduction and rapid spread of ticks and tick-borne pathogens in-to areas where previously absent. These movements are intense in the Western highlands of Cameroon and promote the circulation of ticks. Thus, the need to assess the abundance and distribution of tick vectors with the aim of establishing a baseline for monitoring future spread of tick borne-diseases in the Menoua Division is urgent. A longitudinal study was carried out on 360 cattle selected at the Nkong-Ni municipal slaughterhouse for tick collection. All visible adult ticks were collected on each animal, preserved in 70% ethanol, counted and morphologically identified. The total of 8,492 adult ticks belonged to 14 species grouped into 5 genera. The relative abundance of the 3 most prominent species was *Rhipicephalus decoloratus* (50.6%), *Amblyomma variegatum* (25.0%) and *Rhipicephalus microplus* (7.6%). *R. microplus* was found on cattle all over the year and could be due to interconnection of herds through trade with an important relative abundance observed from October to January. Out of the 360 cattle examined, 312 (86.66%) were infested. Animals were 6 times more infested in the dry than in the rainy season with a relative risk of infestation greater in November, January and March compared to other months ($p<0.05$). Mean tick counts were significantly higher in cross than local breeds cattle, in juveniles and adults than calves as well as during the dry than the rainy season ($p<0.05$). This study showed that many tick species hinder the development of cattle productivity in Menoua Division, especially with the introduction and establishment of *R. microplus*. This calls for an urgent response to safeguard livestock sector in this area.

Keywords: *Rhipicephalus microplus*, Tick-borne diseases, Cattle trade, Menoua Division, Cameroon.

Introduction
The Western highlands of Cameroon are recognized as an important livestock production zone [1]. Cattle productivity plays an important role in the economy of the country [2]. However, the output of this sector is affected by health problems and other issues such as tick infestation. These obligate hematophagous arthropods of significant economic and sanitary importance affecting human and animal health worldwide [3]. Nowadays, almost 900 species are known and divided into three families: the Nuttalliellidae (comprises a single genus and species), the Ixodidae or hard ticks (includes 14 genera and ~700 species), and the Argasidae or soft ticks (made of 5 genera and ~200 species) [4, 5]. They are widely distributed in the world [6] and are found in several biogeographical areas both in tropical and temperate zones parasitizing a large diversity of hosts [7]. Ticks affect the production of over 80% of the world's cattle population [8] and are ranked as the most economically important ectoparasites of livestock in the tropics, including in sub-Saharan Africa [9]. Their direct effects on cattle are anaemia, irritation, inflammation, paralysis, allergies, abscesses, hypersensitivity, immuno suppression and skin deterioration at the biting site which often leads to reduction in weight gain and milk yield [10, 11]. More importantly, ticks can also transmit severe pathogens as they are vectors of various pathogens [12]. Nearly 10% of the ~900 known tick species can transmit pathogens, and amongst all arthropods, ticks transmit the greatest variety of pathogenic microorganisms, including bacteria, viruses, protozoans, and helminths [13, 14].

A current global estimate of economic losses from ticks and tick-borne diseases (TBDs) is approximately US$ 20-30 billion per annum [15]. In a study conducted in 1982 at the Wakwa research station situated in the principal cattle rearing region of Cameroon, approximately 63% of animal mortality was attributed to TBDs [16]. This situation has seriously limited attempts to rear high performing exotic dairy cattle breeds which are highly susceptible to tick-borne diseases such as babesiosis, ehrlichiosis and dermatophilosis [17].

The demand for animal food products in Cameroon has increased due to rapid population growth. Several studies and surveys have shown a significant drop in the consumption of beef throughout the country, especially in the large cities [18]. It would have passed from 17-23 kg/inhabitant/year to 6.5-7.5 kg/inhabitant/year over the period of 1980-2002 [19]. This is how the meat coverage rate demand over the period 2008-2015 has fell from 81% to 66%. The level of protein consumption in terms of meat equivalent is 36 kg per capita per year which remains below the standards of the FAO and WHO for a correct diet (43 kg/inhabitant/year). The size of the national herd for nearly 25 years has stagnated at around 6.5 million heads [20], while the population is constantly growing [21].

The few studies conducted on ticks infesting livestock in the Western region of Cameroon have been limited to certain areas, namely the Noun, Nde and the Bamboutos Divisions [22]. The Menoua Division remains less studied despite the influx of animals in this area. It has been shown that livestock trading points represent a strategic contact node in the dissemination of multiple pathogens [23]. Such animal movements can contribute to a shift in the tick population landscape [24]. Additionally, it has been demonstrated that the distribution of many species will expand or contract as a consequence of global warming and climate change [25]. With the recent introduction of the invasive cattle tick *R. microplus* in the southern part of Cameroon, surely from Nigeria [22], a serious threat to livestock is witnessed in the country. Indeed, in addition to being a vector of several pathologies, *R. microplus* seems to be more resistant to the different classes of acaricides available on the market [26] which cannot longer protect animals [27]. This study has therefore been conducted in order to better understand the infestation level of cattle by ticks and to verify the presence of *R. microplus* in Menoua Division in view of developing strategies to combat these ectoparasites and the diseases they transmit.

Materials and Methods

Study site

This study was carried out at the municipal slaughterhouse of the Nkong-Ni Sub-division, located in Menoua Division, West region of Cameroon. This Sub-division is located at latitude 5°29′31″ North and longitude 10°07′10″ East and its average altitude is 1,475 m. It is characterized by an equatorial monsoon-altitude climate, with two types of seasons: a rainy season, from March to October and a dry season, from November to February [28]. Annual precipitation ranges from 1,200mm to 1,800mm. The maximum precipitation is in August and September. The annual average temperature is 20.2°C and fluctuates during the day between 13.4°C and 27.5°C. As for the daily humidity, it varies from 33 to 98% [29]. These characteristics create favorable conditions for maintaining high density of parasitic disease vectors. The cattle herd in the various farms located in this geographical area is made up of around 4,748 heads. In addition, the Nkong-Ni municipal slaughterhouse is an excellent area for the commercialization of cattle and beef for household consumption, traditional/festive ceremonies and finally the supply of cattle to other livestock breeders in Menoua Division. In fact, businessmen involved in the chain obtain their weekly supplies from the livestock markets in Noun Division at up to 70 heads on average every week, that is, 3,360 heads per year [30]. This can promote the introduction of new tick species which therefore influence the epidemiology of main tick-borne diseases in the area. Agriculture and livestock are the main economic activities carried out by the people of Nkong-Ni [31].

Sampling of animals on the field

Were included in this study, cattle of all age groups encountered at the municipal slaughterhouse of Nkong-Ni for which authorization to collect had been approved by the herds managers (shepherds / owners). The field trips were carried out once a month from November 2017 to October 2018. Once on the site, animals were systematically selected using the “sampling interval technique” whereby, 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 the first to the next and so on) [32]. Based on this, 30 cows were selected at each trip and thoroughly inspected for tick collection. The age of cattle was determined by inspection of horn stripes or by teeth examination [33]. Cattle below 2 years of age were considered as calves, those between 2 to 4 years as juveniles and those above 4 years as adults [34]. Added to the determination of the age of cattle, sex, race and origin were also recorded.

Collection and morphological identification of the different tick species

Ticks were collected from 360 cattle of both sexes during the one year period. Cattle were restrained, kept standing and all the body parts were examined and only visible adult ticks were plucked using blunt steel forceps. Due to their small sizes, immature stages were not collected. The ticks collected were preserved in 70% ethanol. Once in the Vector Borne Diseases Laboratory of the Applied Biology and Ecology Research Unit (VBID-URBEA) of the University of Dschang, all the ticks were counted and identified to the genus and species level using a stereomicroscope (up to 100×magnification), followed by the morphological keys of Walker [7] and the Tick.mek application software version 20.1.5.

Data analysis

Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) software version 22.0 and Medcalc version 15.8. Descriptive statistics were used to bring out the different frequency distribution tables of tick species. The Chi-Square test (χ^2) was used to compare the prevalence of infestation while, the Mann-Whitney-Wilcoxon and Kruskal-Wallis tests were used to compare the mean tick count, with respect to qualitative variables. Post hoc analysis was then performed using the Holm P Value adjustment method in a pairwise Wilcoxon rank sum test. P-values less than 0.05 were considered statistically significant.

Ethical approval

This project has been approved by the Institutional Animal Care and Use Committee (IACUC) Nº:

2017/187/UB/FS/HOD/ZAP of the University of Buea. Authorizations to collect ticks on cattle were obtained from the Regional Delegate of the West region and the Divisional Delegate of Menoua Division of the Ministry of Livestock, Fisheries and Animal Industries. The free consent of shepherds and herds owners was also obtained before handling of animals on the field. As compensation for their collaboration, shepherds received advice on tick control methods to improve the fight against tick infestations.

Results

Tick identification and abundance

Out of the total 360 cattle examined, 8,492 ticks of both sexes were collected. Based on their morphology, these ticks were classified into five genera: 6,141 (72.3%) *Rhipicephalus*, 2,126 (25.0%) *Amblyomma*, 140 (1.6%) *Haemaphysalis*, 80 (1.0%) *Hyalomma* and 05 (0.1%) *Ixodes* ($p<0.001$). The majority of ticks infesting cattle in this area belonged to the genera *Rhipicephalus* and *Amblyomma* (Figure 1). These ticks comprised fourteen species: 4,300 (50.6%) *R. decoloratus*, 2,126 (25.0%) *A. variegatum*, 642 (7.6%) *R. microplus*, 410 (4.8%) *R. lunutatus*, 288 (3.4%) *R. muhsamae*, 244 (2.9%) *R. geigyi*, 140 (1.6%) *Hae. laechi*, 125 (1.5%) *R. sanguineus* (1.5), 122 (1.4%) *R. annulatus*, 37 (0.4%) *Hy. rufipes*, 35 (0.4%) *Hy. truncatum*, 10 (0.1%) *R. guiloni*, 08 (0.1%) *Hy. excavatum* and 05 (0.1%) *I. pilosus* (Figure 2). The relative abundance and distribution of each tick species during the one-year period is described in Table 1. *A. variegatum*, *R. microplus* and *R. decoloratus* infest cattle every month while, some species like *Hy. spp* and *R. spp* are only active during the rainy season (from March to October). The annual dynamics of infestation of *A. variegatum* shows that animals are more infested by this tick species either in February or March, which corresponds to the transitional period between the dry and the rainy season. Most tick species parasites of livestock infest cattle in September and October. The herds sampled were found infested by the invasive cattle tick *R. microplus* which was well established in Menoua Division.

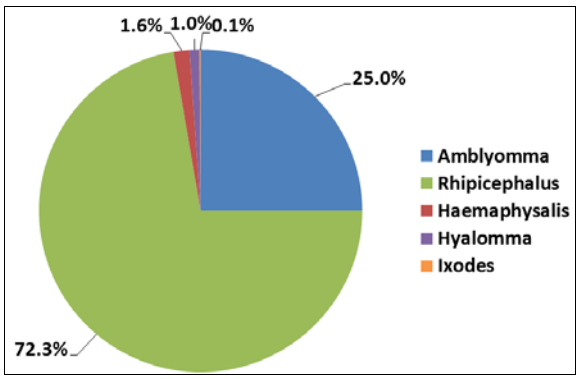

Fig 1: Tick abundance within each genus at the municipal slaughterhouse of Nkong-Ni Sub-division, West Region of Cameroon

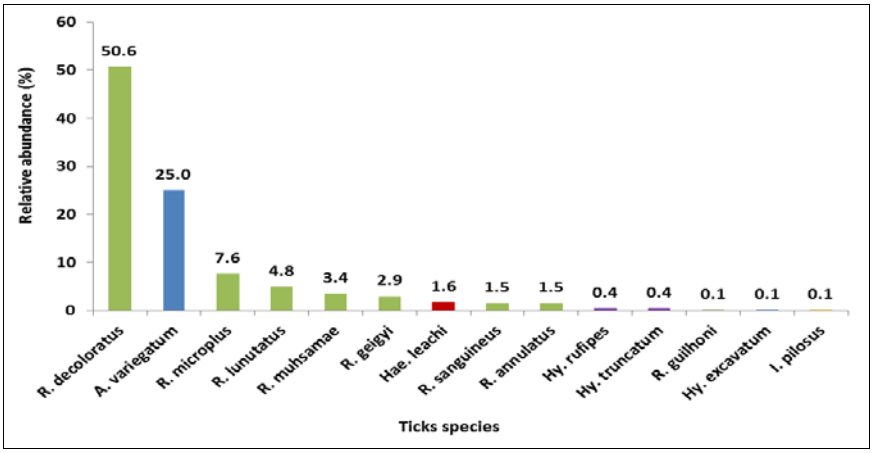

Fig 2: Relative abundance of tick species parasites of cattle at the municipal slaughterhouse of Nkong-Ni Sub-division, West Region of Cameroon

Table 1: Abundance of tick species over a year at the municipal slaughterhouse of Nkong-Ni Sub-division, West Region of Cameroon

	Months												
Tick species	**November**	**December**	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**Total (%)**
A. variegatum	34 (1.6)	98 (4.6)	282 (13.2)	326 (15.3)	572 (26.9)	226 (10.6)	170 (8.0)	246 (11.6)	116 (5.5)	40 (1.9)	8 (0.4)	8 (0.4)	2,126 (25.0)
R. lunutatus	4 (1.0)	4 (1.0)	0 (0)	0 (0)	2 (0.5)	48 (11.7)	0 (0)	0 (0)	108 (26.3)	178 (43.4)	66 (16.1)	0 (0)	410 (4.8)
R. mushamae	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	4 (1.4)	20 (6.9)	156 (54.2)	84 (29.2)	0 (0)	24 (8.3)	0 (0)	288 (3.4)
R. sanguineus	0 (0)	0 (0)	0 (0)	0 (0)	22 (17.6)	11 (8.8)	13 (10.4)	10 (8.0)	18 (14.4)	40 (32.0)	0 (0)	11 (8.8)	125 (1.4)
R. guilhoni	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	10 (100.0)	0 (0)	10 (0.1)
R. decoloratus	746 (17.3)	610 (14.2)	776 (18.0)	472 (11.0)	214 (5.0)	164 (3.8)	264 (6.1)	368 (8.6)	200 (4.7)	100 (2.3)	192 (4.5)	194 (4.5)	4,300 (50.6)
R. microplus	76 (11.8)	72 (11.2)	26 (4.0)	28 (4.40	2 (0.3)	8 (1.2)	102 (15.9)	78 (12.2)	40 (6.2)	30 (4.7)	66 (10.3)	114 (17.8)	642 (7.5)
R. annulatus	14 (11.5)	14 (11.5)	8 (6.6)	0 (0)	6 (4.9)	0 (0)	58 (47.5)	0 (0)	0 (0)	0 (0)	0 (0)	22 (18.0)	122 (1.4)
R. geigyi	46 (18.9)	20 (8.2)	26 (10.7)	44 (18.0)	0 (0)	0 (0)	36 (14.7)	0 (0)	0 (0)	0 (0)	6 (2.5)	66 (27.0)	244 (2.8)
H. rufipes	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	11 (29.7)	17 (45.9)	9 (24.4)	37 (0.4)

H. truncatum	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	7 (20.0)	13 (37.1)	15 (42.9)	35 (0.4)
H. excavatum	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	3 (37.5)	5 (62.5)	8 (0.1)
Ha. laechi	0 (0)	0 (0)	0 (0)	0 (0)	60 (42.8)	33 (23.6)	0 (0)	13 (9.3)	14 (10.0)	20 (14.3)	0 (0)	0 (0)	140 (1.6)
I. pilosus	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	3 (60.0)	2 (40.0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	5 (0.1)
Total (%)	920 (10.8)	819 (9.6)	1118 (13.2)	870 (10.3)	878 (10.3)	496 (5.8)	665 (7.8)	871 (10.3)	580 (6.8)	426 (5.0)	405 (4.8)	444 (5.3)	8,492

Analysis of sex ratio was carried out on the five most abundant species in time and space, namely *A. variegatum*, *R. microplus*, *R. decoloratus*, *R. lunutatus* and *R. mushamae*. The sex ratio varied with species and skewed towards male, except for *R. microplus* and *R. decoloratus* (Table 2).

Table 2: Male: female sex ratio per tick species

Tick species	Male (♂)	Female (♀)	Total	M: F (♂: ♀)
A. variegatum	1,559	567	2,126	2.75:1
B. decoloratus	1,074	3,226	4,300	0.33:1
B. microplus	214	428	642	0.5:1
R. lunutatus	280	130	410	2.15:1
R. mushamae	194	94	288	2.07:1

Prevalence of tick infestation

The prevalence of cattle infested by tick was 86.66% (312/360) and the mean tick count was 23.59 ± 19.46. Prevalence and mean tick count within the study area are presented in table 3 and 4. Tick prevalence was higher in animals sampled within the study area despite the fact that it did not vary according to sex, breeds and age groups. On the other hand, animals were 6 (OR=6.51) times more infested in the dry season 96.7% (79.8-115.9 CI) than in the rainy season 81.7% (70.6-93.9 CI). The relative risk of infestation was greater in November, January and March than others months ($P < 0.05$) where animals were 21 (OR=21.0) times more susceptible to come into contact with these ectoparasites.

Mean tick count were higher in cross breeds (38.2 ± 24.6) than in local breeds (23.4 ± 19.2). A similar result was obtained in juveniles (28.3 ± 11.4) and adults (29.6 ± 20.7) compared to calves (19.2 ± 17.2). The burden of infestation was significantly higher in animals sampled in the dry season (31.1 ± 19.7) than in the rainy season (19.8 ± 18.3) ($P < 0.05$).

Table 3: Prevalence and mean tick count based on sex, breed and age groups in the study area

Category	Number of animals infested/examined	Prevalence % (95% CI)	Odd ratio	Mean tick count ± SD	p-value
Sex					
Male	272/312	87.2 (77.1-98.2)	1.36	23.4 ± 19.2	0.90
Female	40/48	83.3 (59.5-113.2)	Reference	24.8 ± 21.1	
Breeds					
Local	308/342	90.1 (80.3-100.7)	1.81	23.4 ± 19.2^{b}	0.04
Cross	14/18	77.8 (42.5-130.5)	Reference	38.2 ± 24.6^{a}	
Age groups					
Calves	14/16	87.5 (47.8-146.8)	1.07	19.2 ± 17.2^{b}	0.01
Juveniles	116/134	86.6 (71.5-103.8)	0.99	28.3 ± 11.4^{a}	
Adults	182/210	86.7 (74.5-100.2)	Reference	29.6 ± 20.7^{a}	

Legend: 95% CI= 95% Confidence interval; SD=Standard deviation; values followed by the same letter are not significantly different ($p<0.05$)

Table 4: Prevalence and mean tick count according to months and seasons in the study area

Category	Number of animals infested/examined	Prevalence % (95% CI)	Odd ratio	Mean tick count ± SD	p-value
Months					
November	30/30	100 (67.5-142.8)	21.00*	30.7 ± 21.7^{a}	<0.001
December	28/30	93.3 (62.0-134.9)	4.66	27.3 ± 25.6$^{a, b}$	
January	30/30	100 (67.5-142.8)	21.00*	37.3 ± 15.2^{a}	
February	29/30	96.7 (64.7-138.8)	9.66*	29.1 ± 13.4^{a}	
March	30/30	100 (67.5-142.8)	21.00*	39.3 ± 18.4^{a}	
April	24/30	80.0 (51.3-119.3)	1.33	16.5 ± 7.2^{c}	
May	20/30	66.7 (40.7-102.9)	Reference	22.1 ± 17.6^{b}	
June	24/30	80.0 (51.3-119.3)	1.33	30.7 ± 21.8^{a}	
July	26/30	86.7 (56.6-126.9)	2.17	21.2 ± 24.6^{b}	
August	25/30	83.3 (53.9-123.1)	1.67	19.9 ± 15.3^{b}	
September	22/30	73.3 (45.9-111.1)	0.92	14.5 ± 13.9^{c}	
October	24/30	80.0 (51.3-119.3)	1.33	14.8 ± 17.5^{c}	
Seasons					
Rainy	196/240	81.7 (70.6-93.9)	Reference	19.8 ± 18.3^{b}	<0.001
Dry	116/120	96.7 (79.8-115.9)	6.51*	31.1 ± 19.7^{a}	

Legend: 95% CI= 95% Confidence interval; Odd ratio*= risk of infestation significantly higher;
SD=Standard deviation; values followed by the same letter are not significantly different ($p<0.05$)

Discussion

In this survey, a total 8,492 ticks were collected from of 312 animals yielding an overall prevalence of 86.66%. The identification of these specimens revealed the presence of 14 species grouped into 5 genera. This high prevalence could be attributed to difficulties encountered by breeders to fight against ticks with acaricides. Indeed, the latter are confronted with the high cost of acaricides and the limits of their use as recommended by the manufacturers, the availability of effective molecules amongst counterfeit products, the development of resistance in tick populations and the presence of engorged females in vegetations and intermediate

stages on small ruminants [35, 36, 26, 37].

The great diversity observed (14 tick species) could be attributed to the origin of animals and the climatic conditions favorable to the development of ticks in the highland areas of western Cameroon. The cattle sampled in this study came from the main cattle markets located in the Adamawa, West and North-West regions. According to Motta *et al.* [23], livestock trading points represent a strategic contact node in the dissemination of ticks and tick-borne diseases. The agro-ecological zone of the western highlands is characterized by an equatorial climate which favors the installation of a significant plant cover and a litter of abundant dead leaves which proves to be a favorable environment for the development and maintenance of ticks. Moreover, these conditions are ideal for the survival of the preferred hosts of these ectoparasites like cattle, sheep, goats, horses, birds and small ruminants. McCoy *et al.* [38] demonstrated that the presence, development and distribution of ticks in an ecosystem are dependent on various biotic and abiotic factors such as climate [39, 40], ecological conditions [41] and host availability [42].

Rhipicephalus (B.) decoloratus, *A. variegatum* and *R. (B.) microplus* were the most abundant species infesting animals throughout the year. The strong dominance of *R. (B.) decoloratus* and *R. microplus* could be explained by their enormous reproductive potential and the simplicity of their life cycle which is monoxene. The 3 developmental stages (larva, nymph and adult) feed on a single host type, namely cattle which are their preferred hosts [7, 43]. In fact, a female can lay between 2,000 to 20,000 eggs in one lay and accomplish 4 to 5 generations of offspring in a year, which is not the case with *A. variegatum* which is rather abundant in the rainy season [7, 44]. According to Chartier *et al.* [37], the vast majority of ticks in the tropics appear in the rainy season. Otherwise, the annual dynamics of infestation of cattle by *A. variegatum* shows the peak of activity between the transitional period of the dry and rainy season. This could be due to the behavioral diapause developed by this species when infestation conditions are not guaranteed. In fact, Stachurski [45], showed that in areas where the annual rainfall is greater than 500mm, the adults of this tick are present in pastures for 3 to 6 months, remain static in their hiding place and only becomes active when rain returns.

This study reports for the first time, the presence of the invasive tick species *R. microplus* on cattle in Menoua Division. This tick species infests cattle all over the year with an important relative abundance observed from October to January. This is probably the result of a rapid dissemination of ticks through the cattle trade network as demonstrated by Motta *et al.* [23] who analyzed cattle trade network within Cameroon and across the borders. The authors characterized the cattle trade network in Cameroon as a “small world” network which is favorable to the spread of vectors and their associated pathogens. One possible route of introduction of *R. microplus* in our study area is cattle movement from Nigeria due to cross-border transhumance since a recent study has confirmed the presence of *R. microplus* in Nigeria [46]. According to Silatsa *et al.* [47], *R. microplus* is invading Cameroon to the detriment of *R. decoloratus* and has already colonized 4 of the 5 agro-ecological zones in the country.

The association *A. variegatum* and *R. microplus* on cattle sampled in the study area does not suggest a better future for animal production in the Menoua Division. Indeed, *A. variegatum* is the main vector of *Ehrlichia ruminantium* and has a ubiquitous distribution throughout the year in the study area. Results of this study revealed that this tick species was the second most prevalent tick species in terms of distribution after *R. decoloratus*. This finding is consistent with previous studies that reported occurrence of *A. variegatum* across the entire country throughout the year [48, 49]. *Amblyomma variegatum* also transmits the protozoans *Theileria mutans* and *T. velifera* causing benign theileriosis [50, 51]. This tick has also been associated with dermatophilosis caused by the bacterium *Dermatophilus congolensis*. The disease can affect tick-free cattle but is more severe in cattle infested by *A. variegatum* [52]. The role of this tick in the development of dermatophilosis was demonstrated to be promoted by immunosuppression that occurs after tick-feeding and predispose entry of the bacteria into the skin [53].

With regards to *R. microplus*, it is the most important ectoparasite and disease vector of livestock globally. In all countries recently invaded by this tick, it quickly emerged as the species associated with the greatest economic losses in cattle breeding [54] for 3 main reasons: the very weak immune response of certain taurine breeds to this tick; its vectorial competence for virulent pathogens in livestock (*Babesia bigemina*, *B.bovis* and *Anaplasma marginale*) [55] and its ability to rapidly develop resistance against acaricides [56-59]. Moreover, this tick is also involved in the transmission of pathogens usually harbored by native tick species. It is the case of the bacterium *E. ruminantium* which is twice better transmitted by *R. microplus* than its native vector *A. variegatum*. *R. microplus* is also capable of maintaining this bacteria in its offspring population through transovarian and transstadial transmissions which is not the case of *A. variegatum* [60].

The observed sex ratio of tick species collected in the present study varied from one species to another. The male to female sex ratio in *A. variegatum*, *R. lunutatus* and *R. mushamae* showed that males were present in greater number than females. These results agree with previous reports [61, 62]. This is probably attributed to the fact that fully engorged females tick drop-off to the ground to lay eggs while males tend to remain on the host up to several months to continue feeding and mating with other females as has been observed by Salomon *et al.* [63] and Tamiru *et al.* [64]. The low male to female ratio observed for *R. microplus* and *R. decoloratus* could imply that males were not collected in large numbers due to their small sizes, since only visible adults were picked during sampling. The large proportion of females increases the risk of blood loss and eventually anaemia in cattle [65].

Conclusion

This study confirms for the first time the introduction and establishment of the invasive tick *R. microplus* in Menoua Division as a result of cattle trade. Many tick species hinder the development of cattle productivity in the study area and their relative abundances varied according to climatic conditions. *Rhipicephalus decoloratus*, *A. variegatum* and *R. microplus* were found to be the most prevalent tick species. In order to reduce and avoid losses incurred by ticks, effective tick control programs should be formulated and implemented at the regional level as well as systematically treating animals before their transfer into livestock markets.

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