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Original Article

Prevalence, seasonal distribution, and diversity of tick species in Bié Province, Angola

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Abstract
Introduction: Livestock is vital to Angola's economy, with cattle farming being especially important in Bié Province. Productivity is hampered by tick (Ixodida: Ixodidae) infestation, causing damage and potential transmission of pathogens. Despite known tick diversity in Angola, recent data for Bié Province are lacking.
Methodology: A cross-sectional survey was conducted from January to August 2024 in Bié Province across 11 localities, covering commercial and family-based cattle systems. Systematic random sampling was used to examine 686 cattle for ticks during early dry and rainy seasons. Ticks were collected from 7 anatomical regions and morphologically identified; the data were analyzed for seasonal variation, spatial distribution, and gender ratio.
Results: A total of 3,136 adult ticks were collected from 686 cattle (30.3% infestation rate). Ten species across 3 genera were identified, namely *Rhipicephalus*, *Amblyomma*, and *Hyalomma*. *Rhipicephalus evertsi mimeticus* was the most prevalent (27.9%), followed by *R. evertsi evertsi* (13.2%), *R. (Boophilus) decoloratus* (13.1%), and *Amblyomma variegatum* (12.3%). Tick abundance was quite similar between seasons, and females predominated (51.1%). Infestation varies by commune.
Conclusions: The findings reveal substantial tick diversity in Bié Province and confirm ongoing exposure of cattle to multiple species.

Key words: Angola; cattle; Ixodidae; morphology; prevalence.

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Introduction

Livestock is a key sector for the subsistence of Angola and holds strategic importance for the national economy, food security, and nutrition; primarily through the trade of animals and their derivatives [1,2]. Cattle production is mainly concentrated in the central and southern provinces, especially Huíla and Cunene, which together account for 69% of the national herd [1]. In these regions, cattle are not only an economic resource but also hold significant cultural value, often raised for social and family celebrations rather than commercial purposes [3,4].

There are two predominant livestock production systems in Angola: family-based (subsistence) and commercial [5]. Family farming is deeply rooted in the use of natural resources and social structures, influenced by traditional modes of resource management, labor division, and activity diversification [6]. It prioritizes food security and ecological sustainability, typically through pastoralist, agro-pastoralist, or mixed systems [6,7]. However, this sector faces numerous challenges, such as poor infrastructure, limited access to markets and veterinary services, and high vulnerability to external shocks and climatic risks [8,9].

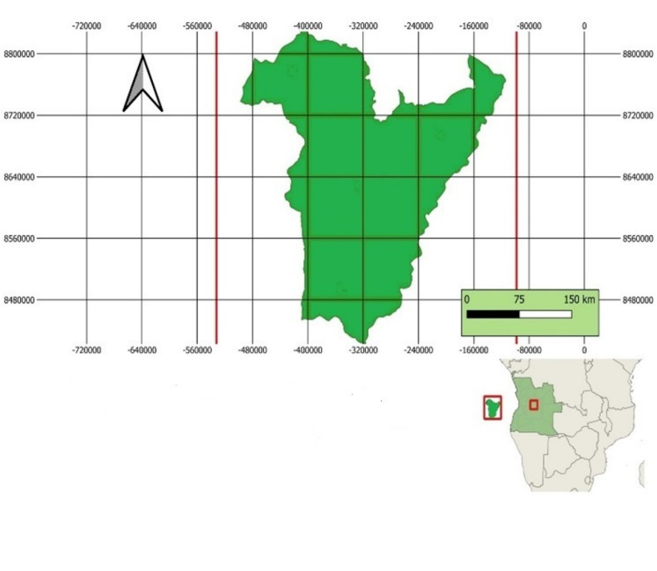
Commercial farming has followed a distinct trajectory. Prior to independence in 1975, it was dominated by family-run and corporate farms, often involved in land disputes. After independence, many farms were abandoned due to conflict and poor management, with much of the land later occupied by rural communities [10]. There has been a resurgence of commercial agriculture aimed at supplying urban markets since 2002, creating a dual system in which modern commercial operations coexist with traditional family farming. Nevertheless, both systems rely heavily on natural pastures, which are vulnerable to overgrazing and require proper management [10].

According to the Institute of Veterinary Services (ISV), a sub-sector of the Ministry of Agriculture and Fisheries (MINAGRIP), animal production in Angola totalled 341,900 tons in 2020–2021, including beef, pork, goat, sheep, and poultry [5]. Poultry dominates national meat production, followed by goat and then beef, which comprises approximately 31.0% of the total [6,7]. Despite its economic importance, the livestock sector in Angola continues to show low productivity and contributes marginally to the national economy [8,9]. This is largely due to limitations in the genetic potential of local breeds, low reproductive efficiency, suboptimal nutrition, high prevalence of infectious diseases, and inadequate veterinary support [4,10]. Additional constraints include limited access to water, insufficient private sector expertise, and a general preference among technicians for public sector employment due to greater job stability [4].

Among the various constraints, tick infestations represent a major challenge to cattle health and productivity [11]. Ticks (Ixodida: Ixodidae) affect livestock at all life stages, with larvae and nymphs typically infesting small hosts [12]. They are globally recognized as vectors of numerous pathogens, including *Rickettsia*, helminths, protozoa, and various viruses [13]. Tick-borne diseases (TBDs) are widely reported in tropical and subtropical regions [14] and have major impacts on livestock due to the broad range of microorganisms they transmit [12,15]. Favorable environmental conditions in tropical climates facilitate high reproductive rates of ticks, which in turn increase the risk of disease transmission [16,17].

Several tick genera, including *Amblyomma*, *Rhipicephalus*, and *Hyalomma*, are particularly important for veterinary and public health. These genera are known to transmit pathogens such as *Anaplasma*, *Babesia*, *Theileria*, and *Ehrlichia* [12,18,19]. Furthermore, increasing resistance to commonly used acaricides has become a serious concern, necessitating integrated tick control strategies tailored to local ecological conditions [15].

Figure 1. Map of the study area located in the central plateau of Angola.



Angola is believed to host one of the most diverse tick faunas in sub-Saharan Africa [20]. However, the available taxonomic studies are limited and outdated, with most research published over 60 years ago [21–23]. These early studies documented tick diversity across different hosts and regions, contributing to knowledge on host-parasite interactions and species distribution [12]. Despite this historical insight, the current understanding of TBD prevalence and tick biodiversity remains insufficient [21].

Although recent studies have identified various tick species and associated pathogens in Angola [16,22–24], significant gaps persist especially regarding the genetic characterization of ticks and tick-borne pathogens (TBPs) [16]. This deficiency is particularly evident in Bié Province, a region where livestock plays a vital role in local livelihoods and food security [25]. The only available data for Bié dates to 1954, citing just 3 species: *Rhipicephalus tricuspis*, *Rhipicephalus pravus*, and *Hyalomma transiens* [26]. The absence of updated surveys limits the development of effective diagnostic and control measures and contributes to economic losses in livestock and public health sectors [27].

Given this context, the present study aims to characterize the diversity and prevalence of cattle ticks in Bié Province, and to compare infestation levels between family-based and commercial livestock production systems.

Methodology

Ethics approval

Sampling approval was granted by Angola's Ministry of Agriculture and Forestry (MINAGRIF), the National Biodiversity Institute (INBAC), and Bié's Regional Veterinary Services. Verbal informed consent was obtained from all cattle owners, who were also advised on sanitary measures for tick-infested animals.

Study area and farm profiles

The study was conducted in Bié Province, central Angola (Figure 1). The region spans approximately 70.314 km² and is characterized by diverse climates, including mesothermal and temperate zones [16]. The region's landscapes range from miombo forests to savannahs and grasslands [28]. The average annual temperature is 18 °C, with rainfall exceeding 1,200 mm, concentrated between October and April. The altitude ranges from 1200 up to 1800 m, and relative humidity ranged from 18% to 65%. Farm sizes ranged from 13 to 103 cattle, and included both family and commercial systems [28,29]. This study was conducted on 11 cattle farms (both commercial and family-based) across 6 municipalities in Bié Province, Kuíto, Catabola, Chitembo, Chinguar, Andulo, and Nhareia; selected through systematic random sampling. These areas share similar savannah ecosystems with herbaceous vegetation and sandy to clay-sandy soils. The temperatures ranged from 25 °C to 36 °C, with relative humidity between 37% and 60% in the rainy season [29–31]. The sampling focus was adult animals. Wildlife such as rabbits, snakes, rats, guinea fowl, and wild goats were observed in all sampled areas, indicating the presence of diverse potential tick hosts in the study environment. Family farms rely on local resources, labor, and diversified activities to ensure food security; yet face weak infrastructure, limited market access, and climatic vulnerability. Commercial farms, revitalized since 2002 after war-induced decline, now focus on urban markets. Natural pastures are essential across systems but require improved management to prevent overgrazing.

Sampling design and tick collection

A cross-sectional study was carried out from January to August 2024, during early dry and early rainy seasons. A total of 686 cattle were selected using systematic random sampling. The animals were restrained for visual inspection across 7 body regions. The animals' body was divided into 7 anatomical regions (head, neck, back, thorax/flank, abdomen/inguinal region, perineum/tail, limbs) (Figure 2). Only visible adult ticks were collected using forceps or gloved hands and preserved in 70% ethanol for identification. Some samples were stored in RNAlater® solution [32] for future microbiome analysis.

Tick identification and data analysis

The ticks were morphologically identified under a stereomicroscope at the University of Trás-os-Montes and Alto Douro (UTAD) using standard African tick keys. Species-level diagnosis focused on key traits such as scutum shape, mouthparts, festoons, and pigmentation. Statistical analyses were performed using Stata 14.0. [33]. Tick prevalence between seasons was assessed using Pearson's Chi-square test, while non-parametric tests (Kruskal-Wallis [34], Mann-Whitney U) evaluated tick burden due to non-normal distribution. A mixed-effects logistic regression model [35] with farm as a random effect, identified predictors of infestation, considering climatic, health, and farm management variables. Multicollinearity was checked, and non-independent predictors (e.g., precipitation) were excluded. Sample size was estimated following Thrusfield's formula [36] using a presumed 51.8% prevalence based on the neighboring Huambo Province.

The calculation was based on a 95% confidence interval and an absolute precision of 5%, as follows:

$$n = \frac{Z^2.Pexp.(1-Pexp)}{d^2} \qquad (1)$$

Where: n = sample size of the study population; d = desired absolute precision (5%); $Pexp$ = expected prevalence (51.8%), derived from a study conducted in a neighboring province with similar conditions); Z = Z-score for 95% confidence level (1.96).

Using the above formula, the sample size was calculated as follows:

$$n = \frac{1.96^2.\,0.518\,.0.482}{0.05^2}$$

Where: n = 384

Study area and sampling

A total of 686 cattle were sampled from January to August 2024 during early dry and rainy seasons across 11 farms (family-based and commercial) in Bié Province to ensure representative coverage.

Morphological identification

Ticks were morphologically identified at the Laboratory of Parasitology, UTAD, using stereo-zoom microscopy and standard African tick keys [12,13,32,]. The diagnostic traits included scutum shape, leg colour, mouthparts, festoon count, and ventral plate structure. Special attention was given to the genus *Rhipicephalus* due to its morphological overlap.

Figure 2. Regions of the cattle body where ticks were collected.

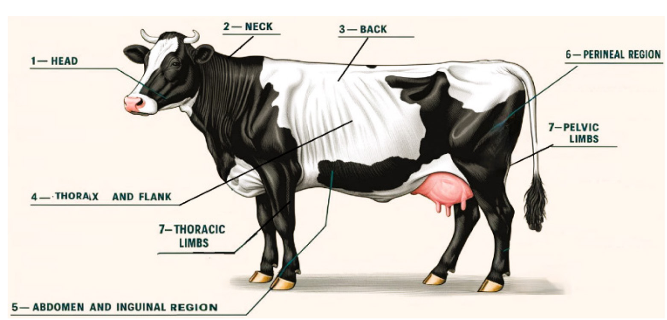


Table 1. Seasonal abundance and gender distribution of tick species identified during dry and wet periods

Tick species	Dry	Wet	Male	Female	Total	Distribution (%)
Rhipicephalus evertsi mimeticus	88	787	47	828	875	27.9
Rhipicephalus evertsi evertsi	301	116	113	304	412	13.2
Rhipicephalus decoloratus	176	233	348	61	409	13.1
Amblyomma variegatum	324	62	330	56	386	12.3
Rhipicephalus microplus	317	3	49	269	315	10.2
Amblyomma pomposum	113	192	271	34	305	9.7
Hyalomma truncatum	98	161	214	45	259	8.3
Rhipicephalus sanguineus	143	4	147	0	147	4.7
Hyalomma rufipes	10	3	12	1	13	0.4
Amblyomma astrion	6	0	5	1	6	0.2
Totals	1576	1560	1535	1597	3136	100

Statistical analyses

The data were recorded in Microsoft Excel and analyzed using Stata v 14.0 [33]. Seasonal differences in tick burden were assessed via Kruskal-Walli's test. Prevalence between seasons was compared using Pearson's Chi-square test. Tick burden was evaluated using Mann-Whitney U test due to non-normal distributions.

A mixed-effects logistic regression model (with farm as a random effect) identified the predictors of infestation. The fixed effects included farm type, dermatophilosis presence, climatic factors (temperature, humidity, cloud cover), and animal condition. Multicollinearity led to the exclusion of precipitation and wildlife presence. Odds ratios (OR) and p values were reported for each predictor. Prevalence and burden were also compared between farm types using Chi-square and Mann-Whitney U tests.

Results

Tick species composition and seasonal distribution

A total of 3,136 adult ixodid ticks were collected from 686 cattle across 11 localities in Bié Province during early dry and rainy seasons. Females accounted for 51.0% and males for 49.0% of ticks (Table 1). Ten species from 3 genera were identified in the dry season, and 9 species from 3 genera in the rainy season (Figure 3). The dominant species included *Rhipicephalus evertsi mimeticus* (27.9%), *R. evertsi evertsi* (13.2%), and *R.* (*Boophilus*) *decoloratus* (13.1%), The ticks *Amblyomma variegatum* (12.3%), and *R. (B.) microplus* (10.1%) were the most abundant in the dry season.

Tick prevalence by season

Prevalence was similar between seasons: 31.3% in the rainy and 29.4% in the dry season, with no significant differences ($\chi^2 = 0.30$, $p = 0.583$) (Table 2). Tick burden also showed no seasonal variation (Kruskal-Wallis, $p = 0.354$). The most prevalent genera were *Amblyomma* (34.3%), *Rhipicephalus* (24.6%), *Rhipicephalus* (*Boophilus*) (23.7%), and *Hyalomma* (16.4%) (Table 3).

Attachment site preferences

Ticks preferred thin-skinned, vascularized regions, with the perineum being the most infested site (Table 4). *R. evertsi mimeticus* and *R. sanguineus* exhibited the broadest range of sites, including neck and anus.

Gender ratio

Gender ratios varied by species. Males predominated in most, including *A. variegatum*, *H. truncatum*, and *R. sanguineus*; while females were more abundant in *R. evertsi mimeticus*, *R. evertsi evertsi*, and *R*. (*B*.) *microplus* (Table 5).

Mixed-effects logistic regression (farm as random effect) showed that commercial farm animals had significantly lower infestation odds (OR = 0.18, p = 0.001). The presence of dermatophilosis was also

Table 3. Percentage of tick genera infesting cattle in the study area across the two seasons.

Tick genus	Number of infested cattle	Prevalence (%)
Amblyomma	71	34.3
Hyalomma	34	16.4
Rhipicephalus	54	25.6
Rhipicephalus Boophilus	49	23.7
Total	208	100

Table 2. Tick prevalence and burden by season.

Season	N	Tick prevalence (%)	Number infested	Pearson χ^2 (df = 1)	*p* value	Mean tick burden (rank sum)	Kruskal-Wallis χ^2 (df = 1)	*p* value
Rainy	342	31.3	107			119,430.5		
Dry	344	29.4	101			116,210.5		
Total	686	30.3	208	0.30	0.583		0.86 (with ties)	0.354

Table 4. Favourable attachments sites of identified ticks.

Tick species	Attachment sites
Amblyomma pomposum	Belly/back, tail/perineum, upper limbs, scrotum, udder
Amblyomma variegatum	Testicles, tail/perineum, upper limbs, scrotum, udder
Amblyomma astrion	Perineum, belly
Hyalomma rufipes	Belly, neck, udder
Hyalomma truncatum	Belly/back, tail/perineum, upper limbs, scrotum, udder, neck
Rhipicephalus (B.) microplus	Tail/perineum, neck, udder
Rhipicephalus (B.) decoloratus	Belly/back, tail/perineum, upper limbs, scrotum, udder
Rhipicephalus evertsi evertsi	Belly/back, tail/perineum, anus, upper limbs, scrotum, udder, testicles
Rhipicephalus evertsi mimeticus	Testicles, tail/perineum, anus, upper limbs, scrotum, udder
Rhipicephalus sanguineus	Testicles, tail/perineum, upper limbs, scrotum, udder, neck

protective (OR = 0.47, p = 0.004). High maximum temperature reduced infestation risk (OR = 0.87, p = 0.033), with cloudy weather showing marginal effect (OR = 0.61, p = 0.059). The other variables were not significant (Table 6).

Tick distribution by farming system

Farm type 1 (family farms) had a significantly higher mean tick burden (8.92 ± 11.34) than commercial farms (0.90 ± 2.85). The Mann-Whitney U test confirmed the difference (p < 0.001), indicating higher infestation in smallholder systems (Table 7).

Spatial and seasonal variation in tick distribution

During the rainy season, *R. evertsi evertsi* was dominant in most communes (e.g., 69.1% in Chinguar), while *R.* (*B.*) *decoloratus* and *H. truncatum* were prevalent in Kua and Dende, respectively. During the dry season, *A. variegatum* dominated overall (20.6%), especially in Kua and Dende. *R.* (*B.*) *microplus* and *R. sanguineus* were also prominent (Table 8).

Table 5. Gender ratio.

Tick species	Males	Females	Gender ratio (M/F)
Rhipicephalus evertsi mimeticus	47	828	0.06:1
Rhipicephalus evertsi evertsi	114	303	0.36:1
Rhipicephalus decoloratus	348	61	5.70:1
Amblyomma variegatum	330	56	5.89:1
Rhipicephalus microplus	50	269	0.18:1
Amblyomma pomposum	271	34	7.97:1
Hyalomma truncatum	214	45	4.76:1
Rhipicephalus sanguineus	147	2	73.50:1
Hyalomma rufipes	12	1	12.00:1
Amblyomma astrion	5	1	5.00:1
Total	1538	1600	0.96:1

Discussion

Several studies over the past six decades have documented a high diversity of tick species in Angola [12,20–22, 37,38]. Despite this, the current knowledge on tick distribution and ecology remains limited and outdated. Understanding the present situation requires considering the frequent importation of cattle from neighboring countries such as Namibia, Zambia, South Africa, Brazil (South America), and Botswana [12,22]. Recent surveys in Huíla, Huambo, and Benguela identified *Amblyomma*, *Hyalomma*, and *Rhipicephalus* as the most prevalent genera [20–22,38]. The genus *Amblyomma* is a vector of various tick-borne hemoparasites (TBHPs) and is infectious in sub-

Table 6. Mixed-effects logistic regression of factors associated with tick infestation (farm as random effect)

Variable	Coefficient (β)	Std. Error	Odds Ratio (OR)	95% CI for OR	*p*-value
Disease status (present)	-0.760	0.260	0.47	0.27 – 0.78	0.004
Farm type 2 (vs type 1)	-1.744	0.535	0.18	0.06 – 0.50	0.001
Max temperature (°C)	-0.143	0.067	0.87	0.76 – 0.99	0.033
Cloudy weather (vs clear)	—	—	0.61	0.36 – 1.02	0.059
Nutritional status	0.237	0.264	1.27	0.77 – 2.13	0.370
Min temperature (°C)	—	—	0.92	0.77 – 1.10	0.337
Relative humidity (%)	-2.458	2.013	—	—	0.222
Altitude (m)	0.000	0.003	—	—	0.919
Health state	0.194	0.316	—	—	0.538

Table 7. Comparison of tick prevalence and burden between farm types.

Variable	Farm type 1	Farm type 2	Test Statistic	*p* value
Number of animals	224	462		
Tick prevalence (%)	57.1% (128/224)	17.3% (80/462)	χ^2 = 113.26	< 0.001
Mean tick burden (SD)	8.92 (11.34)	0.90 (2.85)		
Shapiro-Wilk (normality)	W = 0.898	W = 0.694	z = 6.54; 10.93	< 0.001
Mann-Whitney U (z)			z = 12.19	< 0.001
t-test (mean difference)			diff = 8.02 (95% CI: 6.92–9.12); t = 14.31	< 0.001

Table 8. Tick species counts and percentages (%) per commune and season in the study area.

Commune	Season	*Amblyomma astrion*	*Amblyomma pomposum*	*Amblyomma variegatum*	*Hyalomma rufipes*	*Hyalomma truncatum*	*R (B.) decoloratus*	*R (B.) microplus*	*R. evertsi mimeticus*	*R. evertsi evertsi*	*R. sanguineus*	Total (Sum)
Andulo	Dry	0 (0.0%)	15 (1.0%)	36 (2.3%)	3 (0.2%)	20 (1.3%)	6 (0.4%)	9 (0.6%)	87 (5.5%)	0 (0.0%)	52 (3.3%)	228 (14.5%)
Andulo	Rainy	0 (0.0%)	29 (1.9%)	8 (0.5%)	97 (6.2%)	0 (0.0%)	4 (0.3%)	3 (0.2%)	29 (1.9%)	13 (0.8%)	82 (5.3%)	238 (15.3%)
Catabola	Dry	0 (0.0%)	6 (0.4%)	29 (1.8%)	5 (0.3%)	0 (0.0%)	67 (4.3%)	25 (1.6%)	23 (1.5%)	0 (0.0%)	37 (2.3%)	208 (13.2%)
Catabola	Rainy	0 (0.0%)	3 (0.2%)	0 (0.0%)	4 (0.3%)	0 (0.0%)	1 (0.1%)	2 (0.1%)	10 (0.6%)	0 (0.0%)	10 (0.6%)	30 (1.9%)
Chicala	Dry	0 (0.0%)	15 (1.0%)	33 (2.1%)	2 (0.1%)	13 (0.8%)	16 (1.0%)	0 (0.0%)	36 (2.3%)	0 (0.0%)	0 (0.0%)	115 (7.3%)
Chicala	Rainy	0 (0.0%)	8 (0.5%)	1 (0.1%)	4 (0.3%)	0 (0.0%)	12 (0.8%)	0 (0.0%)	25 (1.6%)	44 (2.8%)	25 (1.6%)	119 (7.6%)
Chinguar	Dry	0 (0.0%)	4 (0.3%)	3 (0.2%)	0 (0.0%)	28 (1.8%)	0 (0.0%)	2 (0.1%)	44 (2.8%)	0 (0.0%)	2 (0.1%)	83 (5.3%)
Chinguar	Rainy	0 (0.0%)	0 (0.0%)	2 (0.1%)	8 (0.5%)	0 (0.0%)	10 (0.6%)	6 (0.4%)	10 (0.6%)	6 (0.4%)	10 (0.6%)	52 (3.3%)
Chitembo	Dry	0 (0.0%)	0 (0.0%)	0 (0.0%)	70 (4.4%)	9 (0.6%)	22 (1.4%)	101 6.4%)	0 (0.0%)	0 (0.0%)	22 (1.4%)	224 (14.2%)
Chitembo	Rainy	0 (0.0%)	6 (0.4%)	0 (0.0%)	4 (0.3%)	0 (0.0%)	3 (0.2%)	3 (0.2%)	13 (0.8%)	1 (0.1%)	13 (0.8%)	43 (2.8%)
Curi	Dry	0 (0.0%)	16 (1.0%)	29 (1.8%)	11 (0.7%)	0 (0.0%)	7 (0.4%)	4 (0.3%)	16 (1.0%)	0 (0.0%)	0 (0.0%)	83 (5.3%)
Curi	Rainy	0 (0.0%)	2 (0.1%)	1 (0.1%)	0 (0.0%)	0 (0.0%)	3 (0.2%)	3 (0.2%)	3 (0.2%)	0 (0.0%)	3 (0.2%)	15 (1.0%)
Dende	Dry	0 (0.0%)	13 (0.8%)	44 (2.8%)	2 (0.1%)	9 (0.6%)	38 (2.4%)	38 (2.4%)	46 (2.9%)	0 (0.0%)	0 (0.0%)	190 (12.1%)
Dende	Rainy	0 (0.0%)	1 (0.1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.1%)	1 (0.1%)	1 (0.1%)	0 (0.0%)	8 (0.5%)	13 (0.8%)
Kaluapanda	Dry	6 (0.4%)	9 (0.6%)	9 (0.6%)	0 (0.0%)	5 (0.3%)	0 (0.0%)	35 (2.2%)	8 (0.5%)	0 (0.0%)	30 (1.9%)	102 (6.5%)
Kaluapanda	Rainy	0 (0.0%)	26 (1.7%)	7 (0.4%)	1 (0.1%)	0 (0.0%)	2 (0.1%)	2 (0.1%)	8 (0.5%)	20 (1.3%)	8 (0.5%)	76 (4.9%)
Kua	Dry	0 (0.0%)	20 (1.3%)	103 (6.5%)	2 (0.1%)	31 (2.0%)	44 (2.8%)	1 (0.1%)	22 (1.4%)	0 (0.0%)	0 (0.0%)	223 (14.2%)
Kua	Rainy	0 (0.0%)	3 (0.2%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	3 (0.2%)	3 (0.2%)	8 (0.5%)	0 (0.0%)	8 (0.5%)	25 (1.6%)
Ndonho	Dry	0 (0.0%)	10 (0.6%)	14 (0.9%)	0 (0.0%)	0 (0.0%)	39 (2.5%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	63 (4.0%)
Ndonho	Rainy	0 (0.0%)	1 (0.1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.1%)	1 (0.1%)	1 (0.1%)	0 (0.0%)	0 (0.0%)	4 (0.3%)
Nhareia	Dry	0 (0.0%)	5 (0.3%)	24 (1.5%)	1 (0.1%)	4 (0.3%)	28 (1.8%)	40 (2.5%)	16 (1.0%)	0 (0.0%)	0 (0.0%)	118 (7.5%)
Nhareia	Rainy	0 (0.0%)	0 (0.0%)	2 (0.1%)	0 (0.0%)	0 (0.0%)	2 (0.1%)	2 (0.1%)	2 (0.1%)	0 (0.0%)	2 (0.1%)	10 (0.6%)

Saharan Africa [39]. Recent research from around the world including the Southern Africa region highlights the high diversity of tick species and the occurrence of major TBHPs vectors such as these three tick genera, their distribution is strongly shaped by cattle movement and cross-border trade, underscoring the importance of integrated control strategies [40–45].This study highlights the dominance of these tick genera in cattle tick infestations in Angola, with several of these species acting as vectors of economically significant pathogens [46,47]. For example, it is well documented that *Rhipicephalus (Boophilus) microplus* is an invasive tick species that has spread across southern Africa, including Angola, largely due to livestock movement. This species competes with native ticks and acts as a key vector for multiple tick-borne diseases [48–51]. Pathogens such as *Rickettsia africae*, *Ehrlichia* spp., *Babesia bigemina*, and *Anaplasma marginale* have been reported, indicating a substantial threat to livestock health [16,46,48,52–55]. Out of the 686 cattle examined in Bié Province, 30.3% were infested with ticks across 10 species and 3 genera, with similar species recorded during both dry and rainy seasons. Tick counts were nearly equal between seasons (dry: 1576; rainy: 1560); and a slight female predominance (51.1%) was observed, likely due to their prolonged feeding and visibility during engorgement [12,51]. The results of the present study revealed that the prevalence of ticks in hosts like cattle (30.3%) is decreased as compared to the previous studies in other provinces such as Huambo [16] where the prevalence of ticks in cattle was more than 50%. This is probably due to an increase in the level of awareness of the farmers on how to reduce tick infestation in their cattle, improvement in the management of animals, and increment of veterinarians per district [21]; in comparison to 10 years ago. In addition to this, the climatic variation is also another factor which may contribute to decrease the prevalence of the tick infestation in the study area. This reduction in tick infestation is also attributed to an increased awareness among farmers about effective control practices, improved livestock management, and enhanced veterinary services, alongside climatic variations that can influence tick population dynamics, [56, 57].

The most prevalent species was *Rhipicephalus evertsi mimeticus* (50.5% in the rainy season), followed by *R. evertsi evertsi* and *R. (B.) decoloratus*, both showing seasonal fluctuations consistent with prior findings [16,21,38]. The invasive *R. (B.) microplus* dominated during the dry season (19.9%), raising concerns due to its acaricide resistance and disease transmission potential [20–22]. This also aligns with the findings of Rehman *et al.* [43] who also reported *R. (B.) microplus* as predominant. According to Madder *et al.*, *R. (B.) microplus* is one of the exotic species that had a rapid introduction and spread in the African countries [58]. *Amblyomma variegatum* was more abundant in the dry season, while in the study conducted by [56] it was the dominant tick in the rainy season in Guinea-Bissau. This may be because the soil in the corrals, especially on family-run farms in the study area, remained constantly wet or humid during the two collection seasons in this study. According to Vaumourin *et al.* [57], the combination of high species diversity and abiotic factors such as rainfall, humidity, and soil moisture in tropical regions favors greater parasite diversity in animals. *A. pomposum* showed distinct seasonal preferences, while *Hyalomma* sp. appeared across both seasons, reflecting ecological adaptability

[12,35,50]. According to Walker *et al.* [12], A. *variegatum* can persist year-round, and local adaptation may explain its abundance in the dry season in the study area. The identification of *R. sanguineus*, typically a canine tick, suggests possible cross-host transmission in rural settings [10,21]. The presence of similar tick fauna in both seasons may result from the limited sampling window, but the overall diversity aligns with historical records from Angola and southern Africa [12,25,36,38]. Species like *Hyalomma rufipes* and *A. astrion*, were rare (< 0.5%). The presence of *A. astrion* likely stems from cattle movement from the coastal provinces [12,20].

No significant seasonal difference in tick prevalence or burden was observed in this study, in contrast to most African reports indicating higher infestation rates during the rainy season [12,15,29]. This deviation may be explained by the continuous grazing of cattle throughout the year in Bié Province, which facilitates sustained tick-host contact, independent of seasonal variation [10]. Moreover, the limited duration of the sampling period might have constrained our ability to detect seasonal trends accurately.

The production system emerged as a critical determinant of tick infestation. Cattle from family farms exhibited significantly higher prevalence (57.1%) and mean burden (8.92 ± 11.34) compared to commercial farms (17.3%; 0.90 ± 2.85), corroborating previous findings associating smallholder systems with reduced tick control efficacy [38,41]. The relatively lower burden in commercial systems is likely due to more frequent acaricide use and pasture management, underscoring the importance of strategic husbandry practices in tick control [12,39].

Tick attachment site preferences mirrored established species-specific behaviors. Most ticks favored highly vascularized, thin-skinned regions, with the perineum being the most common site. However, species like *R. evertsi mimeticus* and *R. sanguineus* displayed broader site selection, which may enhance their potential as vectors due to increased host contact opportunities [12,16].

Gender ratio analyses revealed marked interspecific variation. Male predominant ratios were observed in several species, including *Amblyomma variegatum*, *A. pomposum*, *H. truncatum*, and *R. sanguineus*: consistent with the extended on-host duration and mobility of males in ixodid ticks [12]. The ulcer caused by *Amblyomma* spp. tick serves as a favorable site for secondary bacterial infections, such as those caused by *Dermatophilus congolensis* [12,53]. *Amblyomma variegatum* holds significant economic importance in cattle due to its association with heartwater (cowdriosis) [22], as illustrated by the study carried out by Tawana *et al.* [35].Not only heartwater, but other TBDs represent a large problem for domestic animals, and also for public health in Angola. Notably, extreme male dominance was recorded in *R. sanguineus* (73.5:1) and *H. rufipes* (12.0:1), whereas strong female predominance was noted in *R. evertsi mimeticus* (0.06:1) and *R. (Boophilus) microplus* (0.18:1). Such divergence likely reflects species-specific life history traits, including differences in questing behaviour, survival strategies, and mating dynamics [12,40,42,44].

These gender ratio patterns are ecologically and epidemiologically relevant. Female biased populations may amplify disease transmission risk, given the role of females in blood-feeding and pathogen dissemination [45]. Conversely, male-biased populations might reflect elevated host activity, with implications for the timing and targeting of acaricide-based interventions [59]. Seasonal shifts, developmental synchrony, and life-stage-specific behaviour may further influence gender ratios, highlighting the need for longitudinal and multi-method studies [60].

Finally, accurate species identification remains a challenge, particularly among morphologically similar *Rhipicephalus* species. Walker and Horak, Gomes and Neves, and Nimo-Paintsil *et al*. noted that molecular differentiation can even be difficult [32,49,52]. Ticks belonging to the genus *Rhipicephalus* are epidemiologically important vectors; however, their taxonomic differentiation is often problematic, with immature forms posing the greatest challenge. This taxonomic uncertainty hampers targeted control strategies and emphasizes the need for more extensive genetic studies. Future research should determine whether the pathogens transmitted by these ticks constitute a real threat to cattle health. If confirmed, implementing species-specific and system-appropriate control programs will be essential to support sustainable livestock production in Angola.

Limitations

This study was limited by its short observation period, which may not fully capture seasonal or interannual variations in tick dynamics. The exclusion of immature tick stages could underestimate total infestation levels; and morphological identification, especially within *Rhipicephalus* spp. is better to combine with genetic data.

Conclusions

This study identified 13 tick species affecting cattle in Bié Province, Angola, with no significant seasonal variation in prevalence, but notable differences between farm types. Family farms faced higher tick burdens, likely due to limited control measures. These findings underscore the need for improved tick management, particularly in smallholder systems. To address this, we recommend: (1) strengthening veterinary services and farmer training; (2) regular acaricide use, especially before the rainy season; (3) promoting integrated control practices, including safe traditional methods; (4) assessing productivity impacts of key tick species; and (5) conducting longitudinal studies to explore host-level risk factors. Future research incorporating molecular tools for accurate species confirmation is recommended to reduce infestation risk and improve cattle health.

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Conflict of interest

No conflict of interest is declared.

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