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Prevalance and Identification of Camel Hard Ticks in East and West Hararghe Zones, Oromia Regional State, Ethiopia

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Keywords: Camel; Genera; Hararghe; Prevalence; Tick.

Abbreviations: BCS: Body Condition Score; CSA: Central Statistical Authority; EARO: Ethiopian Agricultural Research Organization; Pas: Peasant Associations; TBDs: Tick Borne Diseases.

Abstract

This study was conducted in the East and West Hararghe Zones, located in the Oromia regional state of Ethiopia, from April 2022 to October 2022. The primary objective was to assess the prevalence of tick infestation and identify the specific tick genera affecting camels. The research included four Peasant Associations (PAs) - Gara Gafa, Boke Wako, Milkaye, and Gobele. Adult ticks were collected from various parts of the camels' bodies. Out of the 384 camels examined, an overall tick infestation prevalence of 81.7% was observed in the study area. Specifically, 60 camels from Gobele, 71 from Milkaye, 84 from Boke Wako, and 99 from Gara Gafa were found to be infested with different tick species, with prevalence rates of 80%, 80.7%, 84%, and 81.8% respectively. A total of 4850 adult tick genera were collected and identified using direct stereo microscopy, including Rhipicephalus, Ambylomma, Hyalomma, and Boophilus. The only statistically significant difference observed was in the body condition of the animals ($p<0.05$), while no significant difference was found in tick infestation between the origins of the animals ($p> 0.05$). The highest level of tick infestation was observed on the Udder/Scrotum (21.3%), while the lowest (5%) was observed on the Back/side of the camels' body region. The high prevalence of tick infestation in the study areas may be attributed to poor management practices, favorable climates, lack of awareness among farmers, and inadequate veterinary health extension services. Therefore, urgent prevention and control strategies are necessary in these areas.

Introduction

Ethiopia is recognized as having the largest livestock population in Africa, and the livestock sector has been a significant contributor to the country's economy. The camel, known for its adaptability to arid and semi-arid environments, is a versatile animal that enables pastoralist communities to thrive in some of the world's most challenging environments [1,2]. Ethiopia is among the countries with the highest population of camels globally, ranking third in Africa after Somalia and Sudan. The country is home to approximately 1,102,119 camels, primarily distributed in the Southern, Eastern, and North Eastern arid and semi-arid regions, notably in Ogaden, Borana, and Afar regions [3]. The one-humped camel (Camellus dromedarius) holds significant importance in Ethiopia's pastoral economy due to its remarkable ability to thrive in environments with limited vegetation [4]. As land degradation continues and the human population rapidly grows, the importance of camels is expected to increase [5].

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Ethiopia's diverse agro-climatic zones and varied environment create favorable conditions for a range of livestock diseases [6]. A multitude of internal and external parasitic diseases have been identified as major challenges affecting the health, productivity, and performance of domestic animals. Ticks are recognized as the most significant ectoparasites globally, inflicting harm through blood-sucking activities. They are prevalent in many countries worldwide, with particular economic impact in tropical and sub-tropical regions [7].

The significance of ticks lies in their ability to transmit a wide array of pathogenic microorganisms, including protozoa, rickettsial, bacterial, spirochetes, and viruses. In Africa, diseases such as Theileriosis, Babesiosis, Anaplasmosis, Rocky Mountain spotted fever, heartwater (cowdriosis), Tularaemia, Lyme disease, Relapsing fever, Louping ill, and African Swine Fever are the primary health and management concerns for livestock [8]. The impact of tick infestation on one-humped camels includes mild to severe anemia, loss of appetite, reduced growth rate, and decreased productivity [9]. Furthermore, ticks cause direct damage through feeding habits, udder and teat damage, scrotal damage, myiasis due to infestation by maggots at damaged sites, and secondary microbial infections. Tick paralysis in camels is a rare syndrome reported only in Sudan, apparently caused by adult Hyalomma spp. and/or Rhipicephalus spp. or nymphs [10].

There are two primary families of ticks, known as Ixodidae or "hard" ticks due to their hard dorsal shield, and Argasidae or "soft" ticks because of their flexible leathery cuticle. The family Ixodidae encompasses around 80% of all tick species, including those of greatest economic significance [11]. In Africa, the most important ticks for livestock health belong to about seven genera, including Amblyomma, Boophilus, Haemaphysalis, Hyalomma, and Rhipicephalus, which are commonly found in Ethiopia. There are 20 species of ticks affecting livestock, all of which have detrimental effects on production and productivity [12,13].

Camels are typically distributed in the dry subtropical areas of Africa and Asia. In Ethiopia, there are approximately 1.06 million camels located mainly in the arid and semi-arid regions of Southern, Eastern, and North Eastern parts of the country, particularly in Borana, Ogaden, and Afar regions [14,15].. However, camel production faces challenges due to various diseases, inadequate veterinary services, feed shortages, and internal and external parasitic diseases. Ticks are a major constraint to the global livestock industry [16,17], causing significant hindrance to animal production in tropical and subtropical regions by transmitting fatal livestock pathogens, leading to blood loss, hide and udder damage, and paralysis [18].

Despite the vital role that camels play in the livelihood of Ethiopian pastoral society and the potential impact of ticks on their productivity, reports on camel ticks in Ethiopia are scarce. In the East and West Hararghe Zones, camels are consistently at risk of tick infestation and tick-borne diseases. Various methods for controlling tick infestation in the area exist, but the challenge persists due to limited coverage of households by the control methods practiced. Additionally, there has been no specific study conducted on the status of hard tick infestation on camels in the West and East Hararghe Zones. Therefore, this study aimed to determine the prevalence of hard ticks on camels and identify the genera of ticks distributed in selected pastoral areas of East and West Hararghe Zones.

Camel hard ticks

General characteristics

Ticks are arthropods closely related to insects and spiders, lacking a spine. They are classified under the phylum Arthropoda, the class Arachnida, and the order Acari [19]. Infestations of domestic animals by ticks are referred to as acariasis due to their classification under the Acari group. There are two primary families of tick species, known as Argasidae and Ixodidae. The Argasidae ticks, also called soft ticks, lack a hard scutum on their bodies and include an important genus that infests cattle, Ornithordores. These ticks remain permanently on their host while feeding (Latif and Walker, 2004). On the other hand, Ixodidae ticks, often referred to as hard ticks, primarily act as disease vectors. This family includes popular genera such as Boophilus, Amblyomma, Rhipicephalus, Haemphysalis, Dermcentoer, Ixodes, and Margaropus, which commonly infest cattle [19].

Both families share a common developmental form with six-legged larvae and eight-legged nymphs that undergo renewed moulting to reach the adult stage. In order to locate their hosts, both families of ticks possess a number of chemoreceptors and Haller's organ located on the tarsus of the first pair of legs [19].

Morphology of hard ticks

Camel can infected with a rangeof different genera of ticks. The most economically important and widely prevalent ticks are the family *Ixodida*e genus; *Amblyomma, Hyalomma, Boophilus, and Rhipicephalus.* Ixodid ticks are characterized by the presence of a rigid chitinous scutum that covers the entire dorsal surface of the adult male where as it extends only for a small area in the female, the nymph and the larvae to permit the abdomen to swell after feeding. They have rounded body, lack a clear boundary between the anterior and posterior body parts and are divided in to two body components that is gnathostoma or capitulum, the mouthparts or a fusion of head, thorax and the ideosoma.

The Mouth part consists of two small retractile mandibles, a pair of short palpi and the toothed probe or hypostome, which projects forward. When engorged, females may increase their weight many times, appear round, and plump. This is because of the elastic cuticula of the female. The presence or absence, shape and size of morphological features such as anal groove, palps, scutum, mouthparts, basis capituli, festoons, spiracles plates, ventral plates, adanal plates, subadanal plates, spur, and others are important in the differentiation of different genera and species of ticks [19].

Biology of hard ticks

Ticks can be categorized into three groups based on the number of hosts they require to complete their life cycle: one-host, two-host, and three-host ticks. One-host ticks, such as all species of Boophilus, complete their entire development on a single host. After emerging from eggs, the larvae attach to a host animal, where they develop into nymphs and then adults. The female drops off after mating and laying eggs, with the entire cycle taking around 19-21 days, but this duration can vary depending on environmental conditions [20].

Two-host ticks, exemplified by species like Rhipicephalus and Hyalomma, hatch from eggs as larvae and attach to a host to feed and develop into nymphs. After dropping off onto the ground, they reach the adult stage in 20-30 days. The adult then seeks another host for feeding, mating, and egg deposition [20,19].

Three-host ticks, including species like Amblyomma, Dermacentor, Ixodes, and most species of Rhipicephalus and Hyalomma, have a more complex life cycle. The larvae emerge from eggs on the ground and feed on a host before dropping off and molting. Nymphs then seek a second host for feeding before molting into adults on the ground. The adult tick then looks for a third host for feeding, mating, and egg deposition before completing the cycle [21]. The entire development cycle of a three-host tick may take up to a year due to variations in the length of time spent in each stage on the ground.

Attachment sites

The specificity of tick attachment sites acts as a natural control on their population, limiting them to certain areas of the host's body. This limitation is influenced by the host, environmental conditions, and the behavior of the ticks. Ticks initially use their front legs to latch onto hosts and then move across the skin to locate a suitable spot for feeding [19]. They tend to target protected areas on the host where optimal conditions for their growth exist and have a preference for specific skin regions for feeding [21].

The response of the host's grooming behavior to the level of irritation at the tick attachment site can impact the distribution of ticks on the host's body. In the case of short-haired hosts exposed to direct sunlight, insulation can hinder successful attachment and engorgement on the animal's back. Certain species exhibit specific preferences for attachment sites where adult ticks are inclined to attach. The selection of tick attachment sites on the host is influenced by factors such as accessibility for feeding, protection from environmental damage, and the ability to overcome these challenges. The location of ticks on the host is associated with the potential for penetration by their mouthparts. Species with short mouthparts, such as Rhipicephalus, Dermacentor, and Haemaphysalis species, typically attach to areas like the head (ear, eye, corner of the mouth), around the neck, anus, udder, and tail. On the other hand, species with long mouthparts, such as Amblyomma and Hyalomma species, tend to attach to lower parts of the body where the skin is thicker, such as the dewlap, armpits, groin, udder, perineum, and around the anus. Smaller ticks like Boophilus do not exhibit a distinct preference and can be found all over the host's body [22].

Epidemiology of ticks

Ticks are found in both temperate and tropical regions worldwide. There are approximately 825 known species of ticks that parasitize domestic and wild animals, as well as humans [19]. The family Ixodidae encompasses 13 genera and around 671 or more species of ticks. The epidemiology of ticks is categorized into free-living developmental phase, host-finding phase, and parasitic phase, which are crucial considerations. When ticks are in their free-living developmental phase in the external environment, factors such as temperature and humidity play a significant role in their development and growth [14].

Factors influencing the distribution of ticks

Intrinsic factors: Ticks have specific host species to which they are well-suited, often within a group of similar species. They thrive on hosts such as camels and other members of the Camelidae family, as well as wild animals like buffalo. In plains and savannas, certain species of ticks like Hyalomma and Rhipicephalus, such as H. marginatum and R. bursa, actively seek out hosts, reducing the risks associated with nymph attachment. Some ticks, like Boophilus, are particularly significant from a veterinary perspective as they are one-host species. The level of host specificity varies among different genera of ixodid ticks. In modern agricultural and livestock environments, ticks show selectivity towards certain vertebrate groups based on their size and mobility [22].

The location of ticks on their host is related to the potential for penetration by their mouthparts. Ticks with short mouthparts, such as Rhipicephalus, Dermacentor, and Haemaphysalis, tend to attach to areas like the head (including within the ear and at the nape of the neck), the anal region, and under the tail on ungulates or camel species. Ticks with longer mouthparts, like Hyalomma and Amblyomma, attach to thicker-skinned areas lower on the body, such as the dewlap, axilla, groin, udder, testes, perineum, and anal margin. Smaller ticks, including all stages of Boophilus and larvae and nymphs of Amblyomma, do not have a strong preference and can be found throughout the body [23].

Extrinsic (ecological) Factors: Previous research conducted in south-western Ethiopia by [20,24,25] and categorized the region based on altitude, rainfall, rain type, and climax vegetation, all of which influence the distribution of tick species in the area. The development and survival of tick eggs and pupae, as well as unfed hatched ticks, are dependent on humid rather than wet conditions. Additionally, the activity of ticks during the day, morning, and evening is influenced by the climatic characteristics of a season and region [22].

Life cycle of ticks

In hard ticks, mating typically occurs on the host, except for Ixodes ticks, where mating may also take place while the ticks are still on vegetation. Male ticks remain on the host and will attempt to mate with multiple females while they are feeding. Females mate only once before they are fully engorged with blood. Once engorged, they detach from the host and have enough stored sperm to fertilize all their eggs. Female hard ticks lay a large number of eggs (2,000-20,000) in a single batch [19].

The life cycle of Ixodid ticks involves four stages: egg, six-legged larvae, eight-legged nymph, and adult. Most hard ticks are relatively immobile and adapt a sit-and-wait strategy rather than actively hunting for hosts [8]. Ticks can be classified into three groups based on the number of hosts they require during their life cycle: one-host, two-host, and three-host ticks [26].

In one-host ticks, all three stages feed on the same host. This is a less common type of life cycle but is found in the entire Boophilus sub-genus of Rhipicephalus and in other genera [26]. The eggs are laid on the soil, and after hatching, the larvae quest for a host on vegetation. After feeding, they remain attached to the host for moulting. The nymphs then feed on the same host and also remain attached. After another moult, the adults hatch and continue feeding on the same host. The entire development cycle mostly takes 19-21 days [19].

In two-host ticks, the larvae and nymphs feed on the same individual host, and the adult will feed on another host. Hyalomma detriyum and Rhipicephalus everts have a two-host life cycle. The entire cycle depends on the time the nymphs need on the ground to find a new host [27]. Three-host ticks require a different host for each stage; they drop off after engorging and moult on the ground [26]. This is the most common type of life cycle. The life cycle of three-host ticks is slow, taking from six months to several years [23,19].

Pathogenic role of ticks

In addition to causing mechanical damage and blood loss, ticks can also have a harmful impact on their hosts due to the presence of toxins in their saliva. These toxins can affect not only the site where the tick attaches but also specific tissues within the host. For example, neurotropic toxins can lead to tick paralysis, while dermotropic toxins can cause sweating sickness [23]. When present in large numbers, ticks can result in damage to hides, reduced production, anemia, and even death in animals. Additionally, they can contribute to increased illness and death during periods of drought, as well as delays in fattening, which means animals need to be held for longer before they can be sold. Furthermore, ticks are significant vectors of diseases [28].

Direct effect

Tick paralysis is a condition that affects both humans and animals, causing sudden weakness and loss of motor function that starts in the lower limbs and moves upward. If the ticks are not removed promptly, the paralysis can lead to respiratory failure and potentially be fatal. This paralysis is frequently observed in young domestic animals that have a high infestation of ticks. The severity of the paralysis is typically linked to the duration of tick feeding and the number of ticks attached to the host [26].

Table 1: Tick that cause paralysis.

Animal	Tick Species	Country
Camel Foals	*D. andersoni*	Australia
Foals	*Rhipicephalus everts*	South Africa
Adult Camel	*Rhipicephalus everts*	Africa

Source: [28].

Blood Loss: Ticks exclusively feed on the blood of their host [19]. Species that become highly engorged consume about three times the amount of blood present at the end of the feeding [23].

Bite injury (wound): When a tick bites, it causes focal tissue death and bleeding at the bite site, followed by an inflammatory reaction that often involves eosinophils. Tick bite wounds can become infected with staphylococcus bacteria, leading to localized skin abscesses or pyaemia [8].

Tick Toxicosis: Some toxins produced by ticks may not have a localized harmful effect, but they can weaken the animals and occasionally promote the development of protozoa that chronically infect the host. This represents an exacerbation of the specific toxic effect of the parasite's saliva [23].

Disease transmission

Ticks are significant vectors of animal diseases due to their blood-feeding habits, as they transmit a wide range of pathogenic viruses, rickettsia, bacteria, and protozoa. Major diseases transmitted by ticks include babesiosis, anaplasmosis, theileriosis, Q-fever, cowdriosis, African swine fever, and others [8].

Treatment and Control

Treatment and control of ticks aim to target specific tick species based on their biological characteristics. The efficacy of acaricides, which are used to control ticks, depends on their rational and methodical use. Understanding the behavior of ticks on host animals is crucial for effective control and eradication measures. There are three primary methods used for tick control, with a recent addition to the list [28,29].

Acaricides

Acaricides, such as arsenic, Amitraz, cyhalothrion, dixathion, ethion, diazinon, and subcutaneously administered ivermectin, are commonly used for tick control. The choice of acaricides depends on factors such as their persistence on the skin and hair coat, the potential for toxic residues in milk or meat, and the development of resistance in local tick populations [28]. Treatment intervals during the tick season may vary depending on the susceptibility of nymphal stages to acaricides.

Pasture spelling

Traditional methods like pasture burning, removal of native fauna, field pillowing, and rotational grazing continue to be important techniques for controlling ticks in extensive range conditions [28,27].

Use resistant breeds

The introduction of Bos indicus breeds of cattle has shown promise in reducing the impact of ticks and tick-borne diseases compared to Bos Taurus breeds. Reports from eastern and southern Africa suggest that European cattle breeds tend to harbor more tick species than zebu types [30].

Vaccination

Vaccination against ticks has shown promise, with crude vaccines made from extracts of semi-engorged adult female B. micropus providing effective immunity. Furthermore, a recombinant vaccine based on a membrane-bound glycoprotein Bm 86 has been isolated and shown to be as effective as the native antigen in controlling acaricidal-resistant ticks [28].

Tick species prevalent in ethiopia

Extensive research has been conducted to study the distribution of tick species on livestock in various regions of the country. Surveys have been carried out in multiple areas including Gamo Gofa [31], Bale [32], Shewa Zone [33], Jimma zone [34], Wolayta, Southern Ethiopia [35], two districts of Somali regional state [36], Asella [37], Holeta Town [38], Chilga, North West Ethiopia [39], in Mekelle [40], the highland area of Harar and Dire Dawa [13], in Borana [41] and Haramaya town [42]. The distribution boundaries of ticks are not fixed and constant but are influenced by a complex interplay of factors such as climate, host density, and host susceptibility [43]. Understanding these contributing factors is crucial for effective strategies to control ticks and Tick-Borne Diseases (TBDs) [44]. Knowledge of the geographical distribution and prevalence of tick species is important for the management of ticks and TBDs [45].

A study carried out in Ethiopia by [46] revealed a prevalence of Amblyomma (40%), Boophilus (20%), Haemaphysalis (0.5%), Hyalomma (1.5%), and Rhipicephalus (37%). However, it is known that over 60 species exist in the country. The distribution of A. varigutum is similar to that of B.decoloratus [24].

Boophilus decoloratus (28%) was the most prevalent tick species found, with heavy infestations observed on crossbreed cattle. Boophilus annulata is limited to Gambella and South West Ethiopia. A. cohaerens is predominant in West Ethiopia (De Castro, 1994), and R. pulchllus was mostly found in south-eastern Ethiopia within the Rift Valley. R. e. everts occupies a wide range of climatic and ecological zones. A. gemma and R. pulchellus are confined to semi-arid areas [24].

A research study conducted in Mekele found that Boophilus infestations accounted for 53.6% of the total, while Amblyomma and Rhepicepulus infestations were 23.9% and 22.5% respectively. The study also revealed that ticks infested cattle kept under extensive production systems at a significantly higher rate compared to those under intensive production systems [47].

In a study carried out on cattle in the Gibe valley of central Ethiopia, it was discovered that B. decoloratus infestations accounted for 34.2%, followed by A. varigatum at 29.8%, R. e. everts at 21.1%, R. praetexatus at 9.03%, A. cohaerens at 4.59%, R. camicasi at 0.59%, H. m. rufipes at 0.14%, and H. trunctum at 0.02%. The research also found that the dewlap and vertical areas of the cattle were the most favored feeding sites for the majority of the collected ticks [30].

Materials and methods

Study area

The study was carried out in the West and East Hararghe Zones within the Oromiya Regional State of Ethiopia. East Hararghe, located in the Oromia Region, is bounded by Bale to the southwest, West Hararghe Zone to the west, Dire Dawa to the north, and the Somali Region to the north and east. The Harari Region is situated within this zone, with its administrative center in Harar.

West Hararghe is another zone in the Oromia Region of Ethiopia, bordered by the Shebelle River to the south (separating it from Bale), Arsi to the southwest, the Afar Region to the northwest, the Somali Region to the north, and East Hararghe to the east. The administrative center of this zone is Chiro. The average altitude ranges from 1000-1750 meters above sea level, with an annual rainfall of 410-820 mm during the long rainy season from July to October, and a short rainy season occurring from March to May. The area has a semi-arid climate, with mean maximum temperatures ranging from 19°C to 30°C. The farming system includes pastoral, agro-pastoral, and urban livelihoods. Livestock populations in the districts are as follows: West Hararghe (35,403 camels, 1,117,575 cattle, 135,963 sheep, 1,112,238 goats, and 281,157 equines) and East Hararghe (395,231 camels, 1,241,557 cattle, 314,134 sheep, 1,151,462 goats, and 300,707 equines) [48].

Study animals

The research focused on single-humped camels (Camelus dromedarius) located in randomly chosen districts within the East and West Hararghe Zones. The study encompassed camels of various ages and genders, and according to the owners' information and, the sampled animals were divided into two age categories: young (<3 years) and adult (>3 years). Following the guidelines of [21], nine specific areas on the back of the camels were meticulously examined for ticks, including the ear, head, neck/brisket, foreleg, belly, rear legs, escutcheon, tail, and shoulder. The study included selected Peasant Associations (PAs) such as Gara Gafa, Boke Wako, Milkaye, and Gobele from the four districts of Gola Oda, Burqa dhintu, Daro labu, and Haramaya in the East and West Hararghe Zones of the Oromia Regional State in Ethiopia. The selection of these PAs was purposeful and based on the camel population in the study areas.

Study design

Between October 2022 and April 2022, a cross-sectional survey was conducted with the goal of determining the prevalence of tick infestation and identifying the species of ticks infesting single-humped camels (Camelus dromedarius) in randomly selected districts within the East and West Hararghe Zones. Furthermore, the study aimed to identify the specific areas on the animals' bodies where ticks were most commonly found, measure the relative tick burden, and examine potential risk factors such as age, gender, origin, and physical condition of the animals.

Sample size setermination

The sample size for the study, representing the total number of camels required, was determined using the formula provided by [49] and employing a simple random sampling method. A 95% confidence interval and a 5% desired absolute precision were taken into consideration during the calculation. Given the absence of prior research in this specific area, a 50% expected prevalence was utilized to compute the necessary sample size for this study. Consequently, the following formula was applied to determine the sample size.

$$n = \frac{1.96^2 \times P_{exp}(1-P_{exp})}{d^2}$$

Where: **n**= required sample size, $\mathbf{P_{exp}}$= expected prevalence and **d**= desired absolute precision. Accordingly, the estimated sample size was 384 animals.

Study Methodology

Sample collection

The camels were thoroughly inspected for ticks, with the assistance of the camel owners or their aides. Specific areas where ticks tend to favor, including the head, neck, sternum, under tail, ventral, scrotum/udder, and back/side surface of the camels' bodies, were meticulously examined through visual inspection and skin palpation. Any visible adult ticks found attached to these areas were carefully collected and gently removed. These collected ticks were then preserved in appropriately labeled collection bottles containing 70% alcohol. The bottles were marked with the date of collection, location, sex, age, and the specific site on the body where the ticks were found. Subsequently, they were transported to the Hirna Regional Veterinary Diagnostic and Research Laboratory for storage and identification of the ticks, following the methods outlined by [21,19].

Hard tick identification

The hard ticks collected from each bottle were transferred onto Petri dishes and observed under a stereo microscope for genus identification, following the tick identification guidelines provided by [19]. The key features used for identification included the scutum, anal groove, festoon (ornamentation), color, size, shape of mouthparts, and color of the legs.

Data management and analysis

The Data gathered during the assessment was inputted into an MS Excel spreadsheet and then examined using STATA® version 11 for Windows. Descriptive statistical analysis was employed to study the prevalence of tick species and their attachment sites. The Chi-square test (X2) was utilized to compare infestation rates in relation to age, sex, origin, and body conditions. A 95% confidence interval and a 5% absolute precision level were applied to ascertain if there were significant differences among the measured parameters.

Results

Prevalence of tick infestation based origin of camels

The study was carried out on camels in four Peasant Associations (PAs) - Gara Gafa, Boke Wako, Milkaye, and Gobele - which were randomly selected from districts in East and West Hararghe Zones. Out of the 384 camels examined, 314 (81.7%) were found to have tick infestations. Specifically, 60 camels from Gobele, 71 from Milkaye, 84 from Boke Wako, and 99 from Gara Gafa were infested with ticks, with prevalence rates of 80%, 80.7%, 84%, and 81.8% respectively. The statistical analysis showed that there was no significant difference in tick infestation based on the origin of the animals (p> 0.05) (Table 2).

Prevalence of tick infestation based on sex, age, body condition categories

In terms of sex, 224 female and 160 male camels were included in the study, with 188 (83.9%) females and 126 (78.5%) males found to be infested with various tick species. The statistical analysis indicated that there was no significant difference in tick infestation rates between the two sexes (X2=3.47, p= 0.062, p> 0.05). The prevalence of tick infestation in adult camels was 84.9%, while in young camels it was 76.3%. However, there was no statistically significant variation detected between the different age groups in terms of tick infestation rates (p> 0.05).

The camels were also categorized based on body condition scoring (BCS) into three groups: good, medium, and poor, with infestation rates of 49.1%, 75.8%, and 95.8% respectively. A statistically significant difference (p=0.000) in infestation rates was observed among camels with different body conditions (Table 3).

Table 2: Prevalence of tick infestation based on origin (location of sampling).

Zones	Districts	Pas	Nº. of examined	Nº. of Positive (%)	X^2	P value
West Hararghe	Daro Labu	Milkaye	88	71 (80.7)	0.0853	0.982
	Burka Dhintu	Boke Wako	100	84 (84)		
Total			188	155 (82.4)		
East Hararghe	Gola Oda	Gara Gafa	121	99 (81.81)		
	Haramaya	Gobele	75	60(80)		
Total			**196**			
G/Total			**384**	**314 (81.7)**		

Table 3: Prevalence of tick infestation based on sex categories.

Variables	Categories	No. of Examined	No. of infested (%)	X^2	P-value
Sex	Male	160	126 (78.5)	3.46	0.061
	Female	224	188 (83.9)		
Age	Young	245	208 (84.9)	1.27	0.246
	Adult	139	106(76.3)		
Body Condition	Good	59	29 (49.1)	-	0.000
	Medium	132	100 (75.8)		
	Poor	193	185 (95.8)		
Total	**384**	**314 (81.7)**			

Distribution of camel ticks Genera

In the research, 4850 adult ticks were gathered from the bodies of 384 camels under examination. The study found eight tick species, distributed across four genera, in the examined regions. The most prevalent tick genera were Rhipicephalus at 38%, Hyalomma at 35.2%, Amblyomma at 21.6%, and Boophilus at 5%.

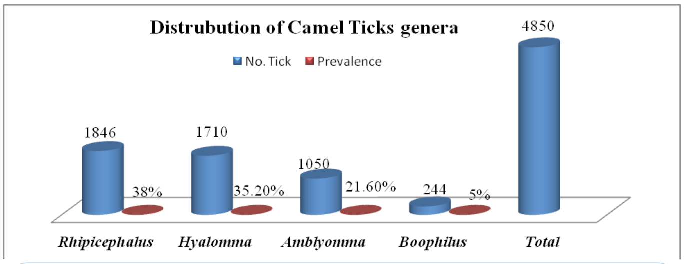

Figure 1: Distribution of camel ticks genera in the study area.

Identified ticks genera and their attachment sites

In this research, prominent tick genera including Hyalomma, Amblyomma, Boophilus, and Rhipicephalus were discovered and identified.

Discussion

Camels play a vital and varied role in the dry regions of Ethiopia. Herders frequently utilize camels for transporting goods and for milk and meat production. Among 384 examined camels, 314 (81.7%) were discovered to be infested with hard ticks. The spread of ticks among camels from various areas was analyzed, and the incidence of hard tick infestation was nearly uniform across the regions: 80% in Gobele, 80.7% in Milkaye, 84% in Boke Wako, and 81.81% in Gara Gafa. The results revealed that there is no statistically significant correlation between the rates of camel infestation by hard ticks and their living areas (PAs).

Table 4: Identified ticks Genera and their attachment sites.

Predilection site	Under tail	Head	Neck	Sternum	Ventral	Udder/Scrotum	Back/side	Total
Hyaloma	443	301	597	226	143	-	-	1710
Amblyoma.	543	-	-	121	-	386	-	1050
Boophilus	-	-	-	-	-	-	244	244
Rhpicephalus	-	416	-	388	395	647	-	1846
Total	**986**	**717**	**597**	**735**	**538**	**1033**	**244**	

This outcome aligns with the findings of [50] in the Jijiga district and [4] in Dire Dawa, but it contradicts the findings of [36] from the Jijiga Zone and [13] from Dire Dawa, which suggest that tick infestation rates are linked to the habitat of camels. This connection is attributed to the influence of climate on tick survival. As [22] observed, the most critical ecological factors affecting tick presence in a habitat include temperature and relative humidity. The absence of this correlation in the present study may be due to the similarities in climatic conditions across the PAs.

The study found that there was no statistically significant difference (p>0.05) in the rates of hard tick infestation between male and female camels. However, the proportion of tick species in female camels (83.9%) was slightly higher than in male camels (78.5%), a result consistent with previous findings by [13] in Ethiopia, [9] in Iran, and [7] in Sudan. This difference may be due to the fact that female camels are often found near their homes for milk production and grazing areas, which provide easy access for ticks, while male camels are mainly used for transportation and are more mobile, making them less susceptible to tick infestation.

The study also revealed a statistically significant association (p<0.05) between the rate of hard tick infestation and the body condition of the camels. Camels with poor Body Condition Scores (BCS) had the highest tick infestation rate (95.8%) (p=0.000), followed by camels with medium BCS (75.8%) (p=0.000), while camels with good BCS had the lowest infestation rate (49.1%). The higher prevalence in poorly conditioned camels may be attributed to their ruffled hair coat, which allows ticks to easily penetrate the hair and attach to the skin. Additionally, the overall prevalence of tick burden did not show a significant difference (p>0.05) between adult and young camels, with similar prevalence rates observed in both age groups (84.9% in adults and 76.3% in young camels), consistent with the findings of [13,51].

In this research, a total of 4850 hard ticks were gathered, representing four different genera of ticks: Rhipicephalus, Hyalomma, Ambylomma, and Boophilus. This outcome aligns with the findings of [50] in their investigation of camel ticks in Jijiga district, Eastern Ethiopia, as well as [13] in their study of camel ticks in and around Dire Dawa, Eastern Ethiopia. The presence of similar hard tick genera in these districts is likely due to unrestricted movement of camels from one area to another, which is common in these neighboring regions.

Rhipicephalus was identified as the most prevalent tick species infesting camels in this study, with a relative prevalence of 38%. This figure is slightly lower than the prevalence reported by, [52,13], who documented prevalence rates of 50%, 46.8%, and 46.8%, respectively. This variation could be attributed to differing climatic conditions and management practices in the pastoral areas. The higher abundance of this species may be linked to its preference for savanna, steppe, and desert climates, as noted by [19]. Rhipicephalus is known to be one of the most common ticks found in North East Africa, the Rift Valley, and east of the Rift Valley from Eritrea in the north to northeastern Tanzania in the south.

Hyalomma was the second most predominant tick species found infesting camels in the current study district, with a relative prevalence of 20.2%. This result is consistent with the findings of [52] at 20.4%, but differs slightly from the results of [13,4,51] who reported prevalence rates of 26.8%, 15.36%, and 15.4% respectively. These findings are contradictory to the results of [5,53], who reported prevalence rates of 1.2% and 3.87% respectively in Ethiopia. This difference may be attributed to varying management practices, agro-ecological conditions, and geographical factors. Hyalomma ticks are known to prefer camels as their hosts [19].

Ambylomma was the third most prevalent tick genus found in the study area, accounting for 11.5% of the total. This result aligns with the findings of [13] at 11.35%, [51] at 13.6%, and [5] at 15.0%. However, it contrasts with the findings of [53,52,45], who reported prevalence rates of 4.10%, 5.79%, and 7.1% respectively. This disparity may be attributed to the use of acaricides and different management practices in various areas. The long mouth parts of Ambylomma ticks are particularly significant in causing udder damage and pose a risk factor for mastitis in camels [5,13].

Hyalomma was the fourth most abundant tick genus, with a prevalence of 8.3% in the study area. This was followed by Hyalomma marginatum rufipes and Ambylomma variegatum, which had slightly similar infestation rates of 6.7% and 5.2% respectively. This finding is consistent with the results of [13] in Ethiopia and [7] in Sudan. The lower infestation rate of these tick species may be due to their requirement for moisture and warmth for survival [54]. Ambylomma variegatum is of great economic importance because it is an efficient vector of Cowdria ruminantum, the organism causing cowdriosis or heartwater [20]. Additionally, ulcers caused by this tick species create favorable sites for secondary bacterial infections such as Dermatophilus congolensis [37].

Boophilus decoloratus was the second least abundant tick species in the study areas, accounting for 5% of the total. This lower number may be related to the fact that, as [20] stated, Boophilus decoloratus is often collected in Ethiopia but does not seem to be abundant anywhere. This tick species is abundant in wetter highlands and sub-highlands receiving more than 800 mm of rainfall annually [38]. Boophilus decoloratus transmits Babesiosis and Anaplasmosis.

Ambylomma lepidium was the least abundant tick species in the study area, with a relative prevalence of 4.9%. The low abundance of this species might be associated with the availability of suitable hosts, as it prefers cattle, or with the climatic factors in the study area. This tick transmits Cowdria ruminantium, which causes heartwater, as well as the protozoans Theileria mutans and Theileria velifera, which cause benign bovine theilerioses [19].

In the study, researchers gathered various types of hard ticks from different parts of camels' bodies and observed that specific tick species displayed a stronger inclination towards particular attachment sites compared to others. The recorded distribution of attachment sites for each tick species during the investigation was as follows: Rhipicephalus pulchellus, Ambylomma lepidium, and Boophilus decoloratus (Head, Sternum, Ventral, and Udder/scrotum), Hyalomma dromedarii (Under tail, Head, and Neck), Hyalomma truncatum (Neck and Sternum), Hyalomma marginatum rufipes (Under tail, Neck, and Ventral), Ambylomma gemma (Under tail and Udder/Scrotum), Ambylomma variegatum (Under tail and Sternum), Ambylomma lepidium (Udder/Scrotum), and Boophilus decoloratus (Back/Side).

The back/side attachment site was discovered to be the least favored, probably due to the thick skin and long hair in that area. Various factors, such as host density, interactions between tick species, and the difficulty of grooming in specific areas, were found to impact the attachment site preferences of ticks [33]. In terms of sex distribution, there were more male ticks than females, except for Boophilus decoloratus. This is likely because fully engorged female ticks detach from the host to lay eggs, while males tend to remain on the host for several months to continue feeding and mating with other females before detaching [34]. Host grooming can easily remove semi-engorged or fully engorged females compared to males. The higher number of females of Boophilus decoloratus in this study may be due to the small size of the males, making them difficult to detect, which could contribute to their underrepresentation. Similar findings have been reported in the country by Ahmed and [50,13,41,43,35].

Conclusion and recommendation

Hard ticks are widely recognized for causing significant economic losses due to disease transmission and decreased livestock output and efficiency. This study's findings indicate a high prevalence (81.7%) of hard tick infestation in camels. Factors such as gender, age, origin, and body condition score were analyzed, and only body condition score exhibited a statistically significant correlation. The camel ticks identified in randomly chosen East and West Hararghe Zones encompass four genera, with Rhipicephalus being the most prevalent and Ambylomma the least. The majority of hard ticks were located on the udder/scrotum and under the tail of the camels, with the back/side being the least favored site.

In light of the study's results, the following recommendations are put forward:

Implementation of an effective tick control strategy in the region.

Raising awareness among livestock owners about the impact of ticks and other external parasites on the health and productivity of their camels.

Further comprehensive investigation into the distribution of ticks in various climatic conditions (seasons) and the diseases they transmit.

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Annexes

Annex 1: Dental Formula-Based Age Determination.

Age	Characteristic change
1.5-2	First incisor emerges
2-2.5	Second incisor emerges
3	Third incisor emerges
3.5-4	Fourth incisor emerges
5	All incisor and canine are in wear
6	$_{\text{First incisor}}$ is level and the neck has emerged from the body
7	Second incisor is level and the neck is visible
8	third insisor is level and the neck is visible, I_4 may be level
9	Forth incisor is level and the neck is visible
10	The dental star is squire in first incisor and in all teeth by 12 years
15	The teeth that are not fallen out are reduce (small round pegs)

Note: In ruminants, the canine is typically considered as the fourth incisor.
Source: Adapted from.

Annex 2: Different types of ticks identified based on specific characteristics.

Characteristics	*Amblyomma*	*Hyalomma*	*Boophilus*	*Rhipicephalus*
Gnatosoma	Long	Long	Short	Short
Basis captulali	Rectangular dorsally	Rectangular dorsally	Hexagon	Hexagon
Coxa I	Two spurs	Bi field	Bi field	Two spurs
festoon	Present	Present/Absent	Absent	Present
Ornamentation	Yes	Yes / No	No	No

Source: Information from [19,55] used to distinguish between various types of ticks based on their specific characteristics.