ADDIS ABABA UNIVERSITY
FACULTY OF VETERINARY MEDICINE

EPIDEMIOLOGY OF TICKS AND TICK-BORNE PROTOZOAL DISEASES OF CATTLE IN DECHA WEREDA, SOUTHERN ETHIOPIA.

A thesis submitted to Faculty of Veterinary Medicine, Addis Ababa University in partial fulfillment of the requirement for the Degree of Master of Science in Tropical Veterinary Epidimiology.

By

YISMASHEWA WOGAYEHU

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YISMASHEWA WOGAYEHU

Examiners	Signature
1. Professor Ph. Dorchies	
2. Dr. David Barret	
3. Dr. Andy Catley	
4. Dr. Mohammed Abdella	

Academic advisor:

Dr. Abebe Wossene

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ABBREVIATIONS

AAU	Addis Ababa University
ANOVA	Analysis of variance
masl	meter above sea level
CCACLP	Central Commission for Agricultural Census of Livestock Population
CCHF	Crimean Congo hemorrhagic fever
DVM	Doctor in Veterinary Medicine
EARO	Ethiopian Agricultural Research Organisation
ECF	East Cost Fever
EDS	Early dry season
ERS	Early rainy season
EVA	Ethiopian Veterinary Association
FAO	Food and Agriculture Organization of the United Nation
FMD	Foot and Mouth Disease
FVM	Faculty of Veterinary Medicine
GDP	Grand domestic product
ICIPE	International center of insect physiology and ecology
ILRAD	International laboratory for research on animal diseases
ILRI	International Livestock Research Institute
LDS	Late dry season
LRS	Late rainy season
MCF	Malignant Catarrhal Fever
OAU	Organization of African union
SNNPRS	Southern nations, nationalities and peoples' regional state
SPSS	Statistical package for social science

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ABSTRACT

An epidemiological investigation of tick and tick borne protozoa parasites was undertaken from September 2004 to March 2005 in Decha wereda, Kaffa zone, SNNPRS. The study was conducted with the aim of determining the distribution, prevalence and seasonal variation of cattle tick species and tick borne protozoa parasites through cross sectional and longitudinal epidemiological study methods. A total of 480 cattle (160 from each highland, midland and lowland geographical zones) were used for cross sectional study while a total of 120 cattle (40 from each geographical zones) were involved in longitudinal study. The longitudinal study was conducted on September, November, January and March that represents late rain, early dry, late dry and early rain seasons, respectively. The result found in the cross sectional study shows that all examined cattle from lowland were positive for tick infestation followed by animals from midland and highland areas with 92.5% and 68.12% prevalence, respectively. Though the difference is not statistically significant between animals with different body conditions, the proportion of infested animals appear to be higher in animals of poor body condition (90.91%) than those in good body condition (85.16%). A significant variation ($p<0.05$) in prevalence of tick infestation was noted between different age groups, the highest being in animals of 3 and half and 4 years old. A total of 4337 adult and immature ticks belonging to three genera were collected during the cross sectional study. Five tick species belonging to three genera (*Amblyomma, Boophilus and Rhipicephalus*) were identified. The most prevalent and abundant tick species was *B. decoloratus* (46.57 %) followed by *A. cohaerens* (22.53%) from the total count. Other tick species collected in small numbers were *A. lepidium* (1.15%), *R. praetextatus* and *R. e. evertsi* (0.14%). Immature ticks were also included in our collections representing a total amount of (28.89%) from the total count. During the longitudinal study a total of 6459 adult and immature ticks comprising six different tick species that belong to four genera namely *Boophilus, Amblyomma, Rhipicephalus, and Haemaphysalis*, were identified. The genus recovered with small number has been *Haemaphysalis* representing (0.03%). Result of estimates of mean tick burden indicated that except among the different age groups, there is a significant difference between different geographical zones, season and body condition ($p<0.05$). The mean tick burden is significantly higher in midland altitudes (22.986), early rainy season (20.713), and in those animals with poor body condition (19.532).

Key words: Epidemiology, tick, cattle, Decha Wereda, Southern Ethiopia.

1. INTRODUCTION

Ethiopia's economy is dominated by the agricultural sector, which contributes about 46.9% of the GDP and employs 85% of the labor force. Besides supplying most domestic food requirements, agriculture provides raw materials for secondary industries and accounts for about 90% of the exports; livestock are an important component to nearly all-farming systems and provide draught power, milk, meat, manure, hides, skins and other products. The size and diversity of Ethiopia's major agro-ecological zones render it suitable for the support of large numbers and classes of livestock. The limitation to increased livestock development (increased productivity) in Ethiopia can be grouped into non-technical and technical constraints. The non-technical constraints are policy issues, land tenure, institutional, infrastructure and budgetary. The major technical constraints include health, feed, genetics and management (Tick modeling workshop, 1997).

Ticks are the most important ecto-parasites of livestock in tropical and sub-tropical areas, and are responsible for severe economic losses both through the direct effects of blood sucking or indirectly as vectors of pathogens and toxin production. Ticks are a cause of much ill health to domestic animals and a cause of considerable economic loss to their owners. In the world, an estimate of US $ 7, 000 million annual losses is caused by tick and tick-borne diseases (FAO, 1984); this estimate provides a guide to regions of the world where *Boophilus microplus* is the only major tick infesting cattle and this figure may indeed be much higher in regions where different tick species are present.

The major losses caused by ticks are due to their ability to transmit protozoan, rickettsial and viral diseases of livestock, which are of great economic importance worldwide (Galloway, 1974 and Jongejan and Uilenberg, 1994). Ticks and the diseases they transmit are widely distributed throughout the world particularly in tropical and sub-tropical countries with special nidality in Africa where there exist a varied fauna of vertebrate animals to their development (Hoogstraal, 1956; FAO, 1984 and Hendrix, 1998).

Each tick infesting an animal may suck out some 0.3 ml of the animal's blood. Even in animals such as zebu breeds that are resistant to ticks this may have a serious effect when the animal is suffering from a low level of nutrition or is pregnant (FAO, 1983). Experiments in Australia have shown that for each *B. microplus* female tick that completes feeding, there is a loss of 0.6g of potential growth by cattle (Walker *et al.*, 2003). There are a number of factors influencing the distribution of ticks, and various tick species have different biological requirement, different geographical distribution, host preference etc., identification is therefore important in the struggle against tick and associated diseases.

Likewise, to other countries, there are a considerable number of economically important livestock diseases occurring in Ethiopia. Among the important diseases, tick-borne diseases are one of the major constraints to the livestock industry. Different tick-borne diseases are known to be present in the country. Seleshi (1994) mentioned the existence of *Anaplasmosis, Babesiosis, Cowdriosis,* and *Theileriosis (T. mutans)*, but their significance in terms of mortality and productive losses and the degree of enzootic stability are not yet very well known. According to Feseha (1983) a conservative estimate of birr 1 million is lost annually through rejection or downgrading of hide and skin. Slight to severe inflammatory reaction of perineal area, udder and teats to the level of gangrene sometimes leading to surgical removal of teats are damages caused by ticks (Tesfanesh, 1993; Solomon, 1994 and Alekaw, 2000).

Despite these problems, the achievement made on the study of tick and tick-borne diseases in Ethiopia in general (except few areas) is not significant and does not cover all regions especially those marginal and remote areas where suitable environment as well as uncontrolled cattle movement exist. The present study is therefore conducted to assess the overall situation of tick and tick-borne protozoal diseases in one of the remotest part of the country, Decha Wereda, Kaffa zone of Southern Ethiopia with the following specific objectives:

1. To determine the type of tick species.
2. To assess any risk factor associated with the occurrence and abundance of the tick species.
3. To determine the prevalence of tick-borne protozoal diseases in the area.

2. LITERATURE REVIEW

2.1. Morphology and classification of ticks

Morphologically ticks are very similar to mites and are grouped under the phylum Arthropoda and order Acarina. Jongejan and Uilenberg (1994) and Walker *et al.* (2003), indicated the presence of at least 840 tick species in two major families, namely *Ixodidae* or "Hard ticks" (so called by virtue of their hard dorsal shield and *Argasidae* or "Soft ticks" (due to their flexible leathery cuticle).

The mouthparts of hard ticks are always anterior and visible from above, the body is oval. Larvae have six legs; nymphs have eight legs and a female type scutum but lack both porose areas on the basis capituli and the genital aperture of the female. The female scutum covers only the anterior portion of the dorsum while in male the scutum extends to the posterior margin of the body. Eyes may be present or absent. Nymphs and adults have a spiracular plate situated laterally, posterior of each hind leg (Hoogstraal, 1956; Kettle, 1984 and Hoskins, 1991).

2.2. Biological characteristics of hard ticks

2.2.1. Feeding

Ticks feed only on the blood of their hosts. According to Radostits *et al.* (1994) all are bloodsuckers and may cause death from anemia. All ticks at each stage of the life cycle are parasitic feeding solely on blood, liquefied tissues, and tend to feed at varying depths according to the species. Their bite is relatively painless; but invasions by large numbers are debilitating (Gray, 1995).

Larvae and nymphs feed on the blood of small wild animals and birds. Adult feed on bigger usually domestic animals. In some species of ticks, the different stage feed on the same host usually domestic animal (Galloway, 1974 and Jongejan and Uilenberg, 1994). The feeding of *Ixodid* ticks is slow because the body wall needs to grow before it can expand to take a very large blood meal. Larvae take typically 3 to 5 days to fully engorge with blood, nymphs 4 to 8 days and females 5 to 20 days. When the ticks have fully engorged with blood they detach from the host's skin and drop to the ground. Ticks at any phase of development, but particularly adult females, suck up considerable amount of host blood (Galloway, 1974).

2.2.2. Mechanism of finding their host

Most ticks are active during warm periods of the year and go into hibernation or become dormant during the cold period; they hide within fissures in the ground, under rocks or in cracks and in buildings (Galloway, 1974). Ticks find their hosts in several ways. Some ticks live in an open environment and crawl onto vegetation to wait for their hosts to pass by. This is a type of ambush and the behavior for waiting on vegetation is called questing (Kettle, 1984 and Walker *et al.*, 2003). Thus in genera such as *Rhipicephalus*, *Haemaphysalis* and *Ixodes* the larvae, nymphs and adults will quest on vegetation. The ticks grab on to the hosts using their front legs and thus crawl over the skin to find a suitable place to attach and feed.

Much of the behavior in ticks is regulated by pheromones; this compound greatly enhances inter-species communication, where vision, auditory and tactile means of communication is not believed to play a significant role (Hamilton, 1992). Pheromones modulate a wide range of behavior, from mating (sex pheromones) to warning other members of the species of impeding danger such as predation (alarm pheromones). Chemical communication via pheromones affecting assembly, mating and host finding has been demonstrated in ticks (Harwood and James, 1969).

Adult ticks of the genera *Amblyomma* and *Hyalomma* are active hunters, they run across the ground to seek hosts that are nearby. The general behavior of seeking hosts in an open environment is described as exophilic. Ticks such as *Argasids* and many *Ixodes* species spend their life cycle in their host's nest and attach to their hosts there. This is called endophilic or nidicolous behavior. A few species of ticks, such as the dog tick *Rhipicephalus sanguineus*, have adapted to living in housing built by humans and will feed on domestic animals there. This is called domestic behavior (Walker *et al.*, 2003).

2.2.3. Reproduction and life cycle

There are three active stages in the life cycle of hard ticks, larvae, nymphs and adult. Each instar takes a blood meal only once and long periods are spent on vegetation between blood meals. In the hard ticks, mating take place on the host, except in species of the genus *Ixodes* where it may also occur when the ticks are still on the vegetation. Male ticks remain on the host and will attempt to mate with many females whilst they are feeding. They transfer a sac of sperm to the female. The females mate only once before they are ready to fully engorge with blood. When they finally engorge, they detach from the host and have enough sperm to fertilize all their eggs (Walker *et al.*, 2003). Oviposition usually begins a few days after the female dropped from the host and continues for several days (FAO, 1984). The female dies afterward. Males remain attached to the host for long period and may mate with other females.

Female hard ticks lay many eggs (2, 000 to 20, 000) in a single batch. On the other hand, female *Argasid* ticks lay repeated small batches of egg. Eggs of all ticks are laid in the physical environment, never on the host (Hoogstraal, 1956 and Walker *et al.*, 2003). The hatching of the egg and the activity of the larvae depend largely on the temperature. Hot conditions are favorable for hatching (Hoogstraal, 1956 and Feseha, 1983).

Three different types of life cycle are recognized based on the number of host species involved in accomplishing the entire life cycle of a given tick species. These are:

2.2.3.1. Trixenic or Three host tick life cycle

Feseha (1983) and Walker *et al.* (2003) stated that this is the commonest type of life cycle and is relatively considered as primitive. Host finding occurs three times. The ticks require three hosts for development, irrespective of the host species. There are three parasitic phases, separated by two phases on the ground when metamorphosis occurs (Morel, 1989). Larvae develop in the eggs until ready to hatch, usually in several weeks depending on the ambient temperature and tick species. Sudden change in temperature may kill the eggs. The newly hatched larva is swollen and soft. It takes several days to harden, lose certain quantity of water and eliminates metabolic waste products accumulated during embryogenesis. After this time, it begins to seek the first host, either lying in wait on a grass blade or moving to hunt actively.

Once the host is found, the blood meal lasts for 3-12 days or more depending on the species and ambient condition, then detaches from the host and falls on the ground, seek shelter and hide in sites such as soil or vegetation. There is complete metamorphosis requiring total immobility and an overall reorganization of the tick, so that the next instars has a different form. The metamorphosis takes 2-8 weeks depending on microclimatic conditions and it ends with the emergence of a nymph. After a period of hardening, the activities of the instars are similar to those of the preceding larval instars in terms of movement and selected host. The feeding period is approximately the same, subsequently it undergoes a complete metamorphosis resulting in the adult female or male whose size may vary considerably depending on how favorable the conditions are for the nymph and larvae. The female feeds once and lays one huge batch of eggs. The depleted female then dies. The male may take several small feeds, mate and then die. The entire life cycle of three host ticks may take from six month to several years and thus it is slow (Walker *et al.*, 2003)

2.2.3.2. Dixenic or two host life cycle

In two-host tick, the three stages develop on two different individuals that may or may not belong to the same species. In the first phase, the engorged larvae moults on the host and the nymph reattaches close by. At the end of the blood meal, the nymph detaches and metamorphosis on the ground. Engorgements of the adults occur during the second parasitic phase. There are only two searches for the host, which eliminates the risks linked with the need for nymphal attachment. The two-host life cycle is similar to one host life cycle but only the larvae and nymphs feed on the same individual host, and the adult will feed on another host.

2.2.3.3. Monoxenic or one host life cycle

This is less common type of life cycle but it occurs in the entire *Boophilus* genus and in some other genera. Fertilized female present on the ground lays its eggs just like any other tick on soil (Hoogstraal, 1956; Jongejan and Uilenberg, 1994). Larvae hatch after several weeks of development and crawl on to vegetation to quest for a host. When they have completed feeding, they remain attached to the host and molting occurs there. The nymphs then feed on the same host and remain attached. After another molt, the adults hatch and then feed on the same host for mating. Thus, all three feedings of any individual tick occur on the same individual host. The life cycle of one-host ticks is usually rapid, for *Boophilus* it takes three weeks for the feedings on the host and two months for egg laying and larval development (Walker *et al.*, 2003). All the instars occur on a single vertebrate attacked by the larvae. Only oviposition, incubation, and host finding by the larvae occur on the ground. The ticks leave the host at the engorged adult stage (Soulsby, 1968 and Morel, 1989).

2.2.4. Host tropism

The life cycle of tick species is associated to different intrinsic and extrinsic factors. The adults of many ticks occur on the grass cover and have access to a wide range of hosts (ungulate carnivores, wild or domestic). They are not specific but selective towards a group of vertebrates based on their size and mobility. Three types of life cycles can be distinguished based on similarities or differences in tropism shown by ticks at different instars (Feseha, 1983 and Morel, 1989).

2.2.4.1. Monotropic cycle

Immature have the same preferences as the adults (e.g. *R. bursa*, *R. e. evertsi*, *Boophilus*, *Hy. a. anatolicum*). The one host *Boophilus* cycle represents the culmination of monotropic cycle (Feseha, 1983 and Morel, 1989). Walker *et al.* (2003) describes *Hy. a. anatolicum* behaving often as a monotrpic and domestic tick with all stages feeding on cattle.

2.2.4.2. Ditropic cycle

The immature parasitize small mammals, birds and reptiles while the adults are only found on large mammals. Exceptions are rare in the ditropic species. Most *Rhipicephalus*, *Dermacentor*, and *Hyalomma* species are found in wild rodents (or in their burrows) in the immature stage (Feseha, 1983 and Morel, 1989).

2.2.4.3. Telotropic cycle

The immature engorges on any available land vertebrate (these may be a group preference) and the adults engorge on large mammals only (Feseha, 1983 and Morel, 1989). Although certain telotropic species may approximate to one of the two cycles mentioned above, they cannot certainly be grouped to any one of them. The difference is useful for ecological tick control.

Although, different ideas and explanations are given for host tropism, Walker *et al.* (2003) describe that the survival of ticks depends on the presence of hosts suitable for reproduction by the adults. As hosts, the larvae and nymphs of two and three host ticks usually employ small wild mammals (mainly rodents), birds and lizards and snakes, while the adult may either feed on large domestic animals or at times on wild mammals (elk, deer, wild boars, wolves, foxes and horse). In some species of ticks, the different stage feed on the same host usually domestic animals (Galloway, 1974). There are hosts known as maintenance hosts and most ticks have characteristic species of hosts to which they are adapted. Hosts are usually in a group of similar species. For example, all the *Boophilus* species are adapted to feed on cattle but some may survive by feeding on sheep or antelope. Because *Boophilus* are one host ticks, all stages must be able to feed on the same species of host (Walker *et al.*, 2003).

2.3. Factors affecting the epidemiology of tick

2.3.1. Habitat

A tick's habitat is composed of a variety of living and non-living things in the space in which it lives, which are good or bad for its survival. Galloway (1974) explains the adaptability of ticks to widely different environmental conditions, some species being adapted to bush forest areas, others to plains, semiarid or desert regions and mountainous terrain. However, ticks have little protection against an enemy except their ease of concealment. They are particularly susceptible to attack during the lethargic pre-molting and the weak post-molting period (Hoogstraal, 1956).

Ticks are adapted to two extremely contrasting components of their habitat, the physical environment and their host. When ticks are molting and then questing in the physical environment they are in danger of drying out, starving and freezing. They are also exposed to predators such as mammals and to pathogens such as fungi. These adverse factors limit the type of habitats that a species will be found in and knowledge of the typical physical habitat of a species is an aid to identification. The needs of the same tick when feeding alter fundamentally because it is no longer in danger of drying out or starving but is in danger of being removed by the host's grooming or having its feeding reduced by host immunity. Most ticks have adaptations in their behavior and physiology of feeding to reduce these host reactions (Cox, 1993 and Walker *et al.*, 2003). Usually these adaptations work best in different type of host. The preference of hosts for certain habitats will influence distribution of hosts and the ticks of them.

2.3.2. Temperature

The temperature and rainfall influences the hatchability pattern and molting period (Dipeolu, 1984). Each species has its particular threshold temperature below that diapauses occurs in all instars. Egg and nymphs development, egg production in engorged female are inhibited while immature and unfed adults become quiescent (Morel, 1989). In tropical grazing area where suitable grass cover does not exist, it has been generally accepted, since temperatures are suitable for development throughout a large part of the year, that the distribution of ticks is mainly governed by rainfall (Urquart *et al.*, 1996). The average weekly and monthly temperature is useful for predicting the activity threshold and optimum temperature. The various genera of ticks have different thresholds of temperature and humidity within which they are active and feed and their distribution is governed by these thresholds.

2.3.3. Relative humidity

Relative humidity is considered at microclimate level. Humid rather than wet condition is essential for the development and survival of eggs, and nymphs, and the survival of unfed hatched ticks. Urquhart *et al.* (1996) mentioned that recent studies in East Africa have shown that the factors underlying the maintenance of the necessary microclimate with a high relative humidity are rather more complex and depend on the transpiration of plant leaves. As long as this continues, adequate humidity is maintained in the microclimate despite the dryness of the ambient temperature. For ticks which have a definite resting site for all their instars, such as nest, earth or caves (pholeophilic species) or at the base of the vegetation, under bushes or in thickets (cryptophilic species), the microhabitat is not subject to significant changes in temperature and humidity (Morel, 1989).

2.3.4. Plant covers (vegetation)

Vegetation is not only the rest of various elements that make up the environment, but it also determines, by its compositions the various microclimates at different level. It is the best ecological integration, which influences the biological phenomena seen at a given point (Morel, 1989). According to Dipeolu (1984) the molting period of larvae and nymphs kept in the open environment as well as the total duration of the life cycle was lower than those of ticks kept in the shade in addition the survival of larvae and nymphs of all tick species studied was lowest during the peak of rain and highest during the dry season. The survival was also generally higher among larvae and nymphs kept in the shade than those kept in the open environment.

2.4. Epidemiology of important cattle tick species of Ethiopia

Ticks are widely distributed and usually seasonal in their activity (Galloway, 1974). The original geographical and ecological range of tick parasites of domestic animals has been vastly extended by human and animal movements, trade, and "modernization" (FAO, 1984).

Studies on Ethiopian tick fauna have begun early in the 19^{th} century. Since then, different scientist and investigators from abroad and the country have been involved in determining the distribution pattern of ticks, the disease they transmit and other associated issues. The investigations made on tick and tick-borne diseases by externship students from the Faculty of Veterinary Medicine are one of the fundamental and important sources of information. Available information in this regard is presented in Annex 1 and 2.

According to Seleshi (1994) the main genera found in Ethiopia are *Amblyomma, Boophilus, Haemaphysalis, Hyalomma* and *Rhipicephalus*. The most important and widespread tick species are *A. variegatum* (vector of *C. ruminantium* and *T. mutans*) and *B. decoloratus* (vector of *A. marginale* and *B. bigemina*). There is no report of the presence of *Rh. appendiculatus* (vector of *T. parva*) in Ethiopia.

Solomon (1996) indicates that more than 50 different tick species are currently known to be present in Ethiopia, infesting all phylogenetic classes of vertebrates from amphibian to mammals; however only a few are of economic importance in terms of geographical spread, effect of feeding on the animal and/or disease transmitted. These include: *A. variegatum; B. decoloratus; Rh. pulchellus, A. cohaerens; Rh. bergeoni; Rh. e. evertsi; H. m. rufipes; H. truncatum; H. dromedarii, A. lepidium;* and *A. gemma*.

2.4.1. Distribution of frequently encountered tick species in Ethiopia

Despite the diversified and unrelated research result in the number and type of tick species, in 1974 Balis and Bergeon established the qualitative hierarchy for tick species of Ethiopia without taking into account the type of host and the region (Feseha, 1983). In his report, from the entire population of ticks, *Rhipicephalus pulchellus* accounted for *30%, Amblyomma variegatum (23%), Amblyomma cohaerens (15.6%), Rhipicephalus simus simus (10%), Rhipicephalus e. evertsi (11%), Amblyomma gemma (4%), Rhipicephalus pravus (2.5%), Rhpicephalus bergeoni (2.2%), Amblyomma lepidium (1.58%) and Boophilus decoloratus (0.34%)*. Bekele (1987) on his part reported that tick infestation appears to be high in lowlands, less in middle altitude regions and much less in high land area accounting for 88.2%, 84.4%, and 64.7% respectively. Their distribution and importance of frequently encountered species is discussed on genera basis as follows.

Genus *Amblyomma*

This is one of the commonest genera of ticks widely distributed all over the country. Out of the 102 species so far identified in this genus, 4 species were reported to exist in Ethiopia occupying different agro ecological zones. They are among the larger ticks and their scuta is colored ("Ornamented"). Their long mouthparts cause abscess formation, which may lead to udder damage and serious secondary infections and most of them incriminated to transmit diseases to animals (FAO, 1984 and Hall, 1985).

Amblyomma variegatum is uniformly dispersed in all regions of Ethiopia from sea level to 8500 feet elevation. It is distributed generally throughout the Ethiopian faunal region except in Northern Sudan, most of Southwest Africa, much of Mozambique and the entire union of South Africa (Hoogstraal, 1956). Massive presence has been recorded in Jibat and Mecha province of Shoa administrative region, in Western parts of Wallega and in the Shire lowlands of Tigray. Abundance was found to be much lower in tropical woodlands and thorn bush vegetation habitats in the Rift valley, and in arid southeastern areas (Feseha, 1983). According to Walker *et al.* (2003), its spread southwards appear to be limited by inter specific competition with *A. hebraeum* with which it shares similar habitats, hosts and sites of attachment. Several studies have shown its widest and predominant distribution in different regions of the country Annex 1 and 2. Similarly, Sileshi *et al.* (2001) have found it in all administrative zones.

Amblyomma cohaerens is prevalent and abundant tick species on cattle in western Ethiopia, where the climate is humid for much of the year (Seleshi *et al.*, 2001). De Castro (1994) has found it as the most abundant tick species in western zone where he could find form Mendi (Wallega) in the north to Maji (Kefa) in the south and as far west as Itang (Ilubabor). Recent works conducted by Yitbarek (2004) in Jimma area revealed the wide distribution of this tick species in the west zone (83% of the total collection). It is absent in the driest northeastern and southeastern ecological zones (Feseha, 1983). *Amblyomma cohaerens* is a specific parasite of the buffalo in African Savannah. It looks more particularly connected with *syncerus caffer aequinoctialis* subspecies and it seems to subsist normally on cattle where there is no initial host or when it has disappeared and very often collection of *A. cohaerens* in Ethiopia coincide in the whole, with dens formation of mountain subtropical grass land. (Morel, 1980). *Amblyomma cohaerens* appears to be abundant in highlands and rare in lowland areas (Bekele, 1987 and Tedla, 1991). FAO (1984) states that among the seven important African *Amblyomma* species, *A. cohaerens* and *A. gemma* are known to be present in Ethiopia.

Amblyomma gemma is reported to be present in the Rift Valley and eastward and appear to be adapted to arid lowland areas. It is mostly common in the semiarid rangelands of Harar administrative region, Sidamo, far less in the Omo Valley (Morel, 1980). It has been found also to be prevalent in the rainy season from March to October and rarely occurs in areas with more than 800 mm of rainfall annually (Feseha, 1983). The distribution of *A. gemma* is between the 250 and 750 mm annual rainfall isohyets, and exclusively concerns to Eastern Africa, the Yemen, Ethiopia, Afar and Isas, Somalia, Kenya, Uganda and Tanzania (Morel, 1980 and Walker *et al.*, 2003). It was the least tick species found in Jimma area (Yitbarek, 2004). It parasitizes ungulate and carnivorous mammals available in its distributional area. Mohamed (1985), Jewaro (1986), Dejenu (1988), Sebsibe (1988), Tedla (1991), Tesfanesh (1993) and Solomon (1994) are among those who have identified and reported this tick species in different regions of Ethiopia.

Amblyomma lepidium occurs in a wide variety of climatic regions, from temperate (highland), to savannah, steppe and desert, but it inhabits most commonly arid habitats with 250-750mm rainfall, making it the second most xerophilous African species of *Amblyomma* after *A. gemma* (Morel, 1980). It is rare in Eastern arid zones and in western wetter areas (Feseha, 1983). It is widespread in central and eastern Sudan, Ethiopia, Southern Somalia, Eastern Uganda, Kenya and Northern region of central Tanzania and is not known to occur out side East Africa (Hoogstraal, 1956). In a survey conducted in western zone of Ethiopia this species was only found in three localities of Gambella, (De Castro, 1994). Its presence has been reported in almost all administrative regions of Ethiopia Annex 1 and 2.

Genus *Rhipicephalus*

Some eight species of *Rhipicephalus* have been identified to occur in different parts of the country of which *Rh. pulchellus*, *Rh. e. evertsi* and *Rh. simis simus* are the dominant ones.

Rhipicephalus pulchellus, which is also known as "zebra tick" because of its white and black stripes and its use of zebras as a favorite host (FAO, 1984 and Walker *et al.* 2003), is highly distributed in the arid region, chiefly in the Rift Valley and eastward (Seleshi *et al.*, 2001). There are only two records from the west of the Valley so far. Different researchers involved in the study of tick distribution have also reported its presence in different regions of the country (Mohamed, 1985; Jewaro, 1986; Dejenu, 1988; Sebsibe, 1988; Tedla, 1991; Tesfanesh, 1993; Solomon, 1994; Surafel, 1996 and Wallaga, 1997). It occurs almost exclusively east of the Rift valley in southeastern Ethiopia, Kenya, Somalia, and northern Tanzania, usually between 300-1800 altitudes masl, (FAO, 1984 and Walker *et al.*, 2003). It infests the ungulates of the dry East Africa at all stages and sticks to the same points as *Amblyomma* or the under parts of cattle, sheep and dromedaries, i.e. Chest, belly, genito-anal area, also in the ears (Morel, 1980).

Rhipicephalus evertsi evertsi also known as the "red-legged tick" shows no apparent preference for particular altitude or rainfall zones or seasons. Its distribution includes desert, steppe, savannah, and temperate climatic regions (Walker *et al.*, 2003). It is present in the Angar Valley in western Ethiopia at 1450 masl and 1450 mm annual rainfall and at Asaita in the eastern Danakil, below 500 masl with about 250 mm rain annually (Feseha, 1983). Seleshi *et al.* (2001) reported its widest distribution in all administrative zones surveyed. It is a two-host tick and is widely distributed throughout the Ethiopian faunal region including the mountains of Yemen and Southwestern Arabia (Hoogstraal, 1956). Though altitude and low temperature do not limit the distribution of red tick, rainfall bellow 10 or 15 inches per annum seems to be a limiting factor (Hoogstraal, 1956). Concerning the attachment, adults attach chiefly under the base of the tail and around the anus, less often in the groin and axillae and on the genitalia and sternum, larvae and nymphs feed deep in the ears.

Rhipicephalus s. simus has been recorded in August in Tegulet and Bulga province of Shoa administrative region at 3100 and in Menagesha province at 2700 masl. Heavy infestation was also recorded in Mahony, a district in the province of chercher in the administrative region of Tigray. It is the probable vector of tick paralysis, (Feseha, 1983). Bekele (1987) has found this species restricted to wetter highland and middle altitude areas infesting mainly cattle, considering it as highland ecotype. On the other hand, Jewaro (1986) has found it occupying a wide range of altitude from 610-1434 masl, i.e., semi arid to sub-humid agro ecological zones. Likewise, Mohamed (1985); Belete (1987); Eshetu (1988); Dejenu (1988); Sebsibe (1988); Tesfanesh (1993); Surafel (1996) and Solomon *et al.* (2003) have reported the existence of this species at different prevalence rate in different parts of the country, although recent finding or report made by Walker *et al.* (2003) indicates its absence from East African region.

Rhipicephalus pravus is encountered in dry savannah and semiarid steppe in the southeast, (Feseha, 1983). *Rhipicephalus pravus* is a tick of temperate highland, savannah, steppe and desert climatic regions. It is found commonly in all the countries of East and North East Africa. It is often found in the same areas as *A. gemma* and is capable of surviving in much drier areas than *Rh. appendiculatus*, (Walker *et al*., 2003). It is rather more indiscriminate in choice of hosts than other *Rhipicephalids*, being common on domestic cattle, sheep, goats and dog equally common on many antelope and carnivores, (Hoogstraal, 1956); but little is known about this tick's association with disease and FAO (1984) indicate the need for investigation of vector capacity of *Rh. pravus* group members. Several workers demonstrated its presence in Ethiopia but is found to be generally less frequent than other *Rhipicephalus* species Annex 1 and 2. Morel (1980) also reported the presence of this species in the country but less abundant in tropical thickets. He found it to be less frequent in Northern eastern Ethiopia, in the Afar plain, the habitat corresponds to dry area receiving form 250 mm to 750 mm of annual rainfall, during a unique rainy season.

Rihpicaphalus bergeoni is restricted to mountain communities and to the neighboring subtropical grasslands of Ethiopia, (Feseha, 1983). Few reports have revealed its presence in the country (Belete, 1987; Jewaro, 1987; Bekele, 1987; Eshetu, 1988 and Tesfanesh, 1993) although Morel (1980) indicated the dominant association of the species in highland forest communities between 2000 to 3000 masl.

Genus *Boophilus*

Boophilus decoloratus which is also known as the blue tick, it is the commonest, widespread and frequent one host cattle tick in Africa. Its distribution pattern is similar to that of *A. variegatum*. It is abundant in wetter highlands and sub-highlands of Ethiopia (Feseha, 1983). Seleshi *et al*. (2001) have found this species in nearly all districts except zone-3 (Afar). This tick species occurs in regions with savannah and temperate climates, typically in grasslands and woodened areas used as cattle pasture. Studies conducted by externship students form the FVM have shown the existence of *B. decoloratus* widely throughout the country, which implies that it is the commonest tick species in Ethiopia Annex 1 and 2.

Jongejan and Uilenberg (1994) indicated the confinement and restrictiveness of *B. decoloratus* to African continent and its competitiveness with *B. microplus*, which has excluded from large areas of Africa. The African *B. decoloratus* is a relatively inefficient vector of *B. bigemina* and cannot transmit *B. bovis* (FAO, 1984).

Bophilus annulatus is often found together with *B. decoloratus*. Cattle are the main hosts of *B. annulatus* but also occasionally sheep, goats, and wild ungulates can support successful completion of the life cycle. It transmits the protozoan *Babesia bigemina* and *Babesia bovis* to cattle, *Anaplasma marginale* and heavy infestations cause damage to hides and probably lead to a reduction in the rate of growth of cattle (Walker *et. al.*, 2003 and Hall, 1985). Except a single record made by Bekele (1987) there is no any notification of the existence and distribution of this tick species in different regions. This tick is well established in the Eastern part of neighboring Sudan but not in Ethiopia, and so poses a major risk to the Ethiopian cattle population that has no immunity to *Babesia bovis* (tick modeling workshop, 1997).

Genus *Hyalomma*

Hyalomma dromedarii: *Hyalomma dromadarii* is common in regions with Mediterranean, steppe and desert climates that are north of the equator in Africa. It is well adapted to extreme dryness of habitat and to camel hosts. In areas where camels are now, less common it seems that cattle can support populations of this tick. In Northeast and East Africa, it occurs in Sudan, Eritrea, Northern, Eastern and Southern Ethiopia, Northern Kenya and Northern Eastern Uganda (Walker *et al.*, 2003). They add that the natural disease relations of this tick are not well understood. *Hyalomma dromedarii* can transmit the protozoan *Theileria annulata* to cattle under laboratory conditions.

Morel (1980), explains that the general distribution of *Hy. dromedarii* coincide with that of hot tropical deserts, it never extends to the cold desert of central Asia, probably it would have some biological flexibility, which would enhance its chances of survival in the difficult environment where it lives. It is the one, which certainly most adapted to conditions of extreme drought. Dejenu (1988) and Sebsibe (1988) reported its presence in Bale and Sidamo respectively without detail information on disease transmission Annex 1.

Hyalomma marginatum rufipes: It is also known as the hairy *Hyalomma* or the coarse legged *Hyalomma*. This is a large robust, shiny black tick. The main hosts of adult *H. m. rufipes* are cattle; also, sheep, goats, horses and wild ungulates are infested. *H. m. rufipes* is widely distributed in much of Africa and has been recorded from every climate region from desert to rain forest. However, the distribution is patchy and it is probably commoner in the dries areas (Walker *et al.*, 2003). It has been found to be the most important vector of the virus causing CCHF in humans; it also transmits *Anaplasma marginale* to cattle. Mohamed (1985); Sebsibe (1988); Dejenu (1988); Eshetu (1988) and Solomon (1993) have confirmed and reported its presence in different regions of the country although in lesser frequency and abundance as compared with other tick species Annex 1 and 2.

According to Morel (1980) *H. m. rufipes* was the most abundant *Hyalomma* collected in the Massai steppes and in thicket Savannahs of Ethiopia. The normal habitat of the species is found between the 150 mm and 750 mm annual rainfall isohyets.

2.5. Pathogenic role of cattle ticks

2.5.1. Mechanical and cytolitic effect (Damage to skin)

Ticks are incriminated to cause serious damage to skin at the site of attachment and that losses to livestock industry from this cause are very considerable (Barnet, 1961). Depending on the attachment point, the presence of ticks alone can cause serious problems apart from the production of toxins and transmission of pathogens and when the animal is heavily parasitized entire areas of the body become painful and hot with abscesses at attachment sites. Local disability and general discomfort that accompany any fairly extensive skin disorders may be produced (Morel, 1989). The damage incurred by large mouthed *Amblyomma* and *Hyalomma* species results in the rejection and downgrading of skins and hides leading to an equivalent loss of 1 million birr annually to Ethiopian livestock industry (Feseha, 1983).

2.5.2. Effect of blood sucking

Ticks are greedy devourers of blood. Severe infestation can cause anemia, which is the product of simple hemorrhage, bone marrow depression resulting from toxic action. The tick feeds by suction from a hemorrhagic cavity alternating with injections of saliva. Engorgement is slow at first then accelerates. According to Feseha (1983) cattle can lose 0.5-1 liter of blood per day through the activities of ticks. On the other hand when dealing with specific species a single adult female *Amblyomma* and *Boophilus* may extract 1-2 ml of blood from a host per day (Barnet, 1961 and Morel, 1989). Walker *et al.* (2003) ratifies this situation by explaining that 10 engorged females of *A. hebreum* per day on cattle can decrease live weight gain by 20 kg over a three-month period.

The ingested blood is concentrated (excretion of water and mineral salts) from the beginning of the meal. High engorgement species therefore ingest about three times the volume of blood found at the end of the meal, leading the animal to the state of anemia. Barnet (1961) mentioned that detectable injury due to blood loss may be marked when large number of ticks are feeding, but it is difficult to give precise figures for the number of ticks which could kill domestic stock from the effects of exsanguinations, theoretically the simultaneous feeding of 6,000 to 10,000 female ticks could kill an adult bovine.

2.5.3. Tick toxicosis or paralysis

Apart from mechanical, cytolitic effect and blood loss, ticks have a specific pathogenic effect due to the presence of toxin in the saliva. It is associated with the engorgement of female ticks especially when the site of attachment is close to the head (Feseha, 1983).

The existence of specific intoxication induced by tick bites is recognized all over the world in practically all species of animals and in man. According to Morel (1989) the toxin responsible for this effect might originate from the ovaries, produced by the activation of the reproductive system after fertilization and during the blood meal (oocyst maturation toxin); As the toxins act on certain host tissues they have got different denomination, the neurotropic toxin which cause tick paralysis and dermotropic toxin responsible of sweating sickness. The sweating sickness is observed in South, Central, and East Africa, affecting cattle, sheep, goats, and pigs. Like tick paralysis, it usually occurs sporadically. It is caused by *Hyalomma truncatum* and has all the characteristic of a toxicosis (Barnet, 1961). If the tick is removed while the symptoms develop, the disorder regresses and disappears in a few days.

2.5.4. Tick worry

A less tangible form of injury is recognized by stockowners under the name of "tick worry". It is concerned partly with the local irritation at the site of feeding partly with blood loss, and partly with secondary infections with bacteria or dipterous larvae following tick bites. The importance of this condition is difficult to evaluate. Nevertheless, it is certain that tick worry is an important source of loss to livestock industry (Barnet, 1961).

The annoyance caused by different tick species obliges the animal to spend energy in effort to avoid or relieve the effects. The result of exhaustion always interferes with production and sometimes proves fatal (Galloway, 1974 and Feseha, 1983).

2.5.5. Disease transmission

As vectors, ticks transmit a greater variety of organisms than any other arthropods. Their pathogenic significance and greatest effect precisely lies in disease transmission as they are able to transmit important protozoal, bacterial, rickettsial, and viral diseases (Kettle, 1984 and Surafel, 1996). As reservoirs of a great variety of pathogenic organisms *Ixodids* are pre-eminently important whether they act or not as vectors. Total losses have been estimated in the range of US $ 7 billion annually with 80% of the world's cattle population of approximately 1,214 million at risk from tick and tick-borne diseases (Seifert, 1996). Losses from tick and tick-borne diseases are of major significance when exotic animals susceptible to them are introduced into the area infested by ticks (FAO, 1984 and Hall, 1985). Some of the major diseases transmitted by ticks are discussed herein below.

2.5.5.1. Streptothricosis

Known also as dermatophilosis, is a chronic disease of cattle, sheep, and goats. The disease is worldwide in distribution, but is generally most economically important in the tropical area of Africa. The mode of transmission of the disease is unclear, but tick infestation principally by *Amblyomma* and *Hyalomma* is considered the true route of infection and their presence on the host encourages pathogenic activity of *Dermatophilus congolensis*, the agent of dermatophilosis (Feseha, 1983 and Morel, 1989). Tick control has been found to substantially decrease the incidence of dermatophilosis. Hagos and Markos (2003) have found remarkable role of ticks as predisposing factors to skin.

2.5.5.2. Anaplasmosis (Gall-sickness)

This is an infectious disease of animals caused by a rickettsial organism of the genus *Anaplasma*, usually transmitted by infected ticks but it may also be transmitted mechanically by biting dipterian flies such as horse flies and *Stomoxys*.

The disease is distributed throughout the tropics corresponding to the range of *Boophilus*, usually considered its principal vector. In cattle, the exotic breeds are more susceptible than East African indigenous zebu and among any breed; calves are generally more resistant to infection than adults (Feseha, 1983 and Morel, 1989).

The two major species-affecting cattle are *A. marginale* and *A. centrale*. The former is the causative agent of malignant anaplasmosis of cattle (Losos, 1986 and Morel, 1989). *Anaplasma marginale* is present in Ethiopia and its vectors such as *B. decoloratus*, *Rh. s. simus*, *Rh. bursa*, and *Rh. sanguineus* are abundant and widely distributed (Feseha, 1983).

Seroprevalence study conducted by Seleshi (1994) indicated that out of 240 serum samples tested, 90% were positive for *A. marginale*. Comparable results also have been reported by Solomon (1994) where 85% of the total serum samples were found to be seropositive for *A. marginale*; Eshetu (1986) and Temesgen (2003) have also reported the presence of *A. marginale* through blood smear examination in their respective area of study.

2.5.5.3. Cowdriosis (Heart water)

It is an infectious and fatal tick-borne disease caused by *Cowdria ruminantium*. It is specific to ruminants of the family *Bovidae* and can only be transmitted by ticks. The preferred sites for the pathogen are endothelial cells, particularly of the nervous system, kidney, spleen, lymph node, ovaries and adrenals.

In nature, six tick species of the genus *Amblyomma* are considered as definite vectors; and the distribution of *Cowdria* corresponds to that of all its vectors. Apart from endothelial cells, it is present in the circulation firmly attached to the red blood cells (Feseha, 1983).

2.5.5.4. Babesiosis (Texas fever, Red water fever, cattle tick fever)

Babesiosis is the name given to a group of diseases of cattle, sheep, pigs, horses and dogs caused by numerous species of *Babesia*, which are transmitted by blood sucking ticks (Hall, 1985; Losos, 1986 and Seifert, 1996). Of more than 70 known species 18 cause diseases in domestic animals, notably in cattle, sheep, goats, horses, pigs, dogs and cats (Seifert, 1996). They are also found in some game animals, which serve as reservoirs of infection. In nature acute, chronic or unapparent type of disease syndrome is found depending on the particular species and is generally characterized by anemia, haemoglobinuria and sometimes jaundice (Hall, 1985; Losos, 1986 and Radostits *et al*., 1994).

It is a disease most commonly encountered in cattle in transit to slaughter or to seasonal or regional pasture, and rarely appears in cattle borne and raised in enzootic areas whose premunition is established gradually as the natural resistance of young animal subsides. Their distribution is governed by the geographical distribution of the insect vector that transmits them. In Africa, *B. decoloratus* is the vector. *Boophylus annulatus* and *B. microplus* are the major vectors of babesiosis, but other *Boophilus, Rhipicephalus* and *Haemaphysalis* species also act as vector (Radostits *et al*., 1994). Young animals may be resistant. Susceptibility usually can be increased by the removal of the spleen (Richardson and Kendall, 1964)

In Ethiopia, the status of tick-borne diseases is not very well established, as there is no concrete data available with regard to their distribution, prevalence, economic importance etc. However, some of the reports from fragmented studies indicated the presence of babesiosis in cattle (Solomon, 1993; Kebre, 1998 and Temesgen, 2003).

2.5.5.5. Theileriosis

These are a group of tick-borne diseases of cattle, water buffalo, sheep, and goats and occasionally of wild ruminants caused by species of protozoa in the genus *Theileria* (Hall, 1985 and Losos, 1986). Because of their heterogeneous form/shape the *Theileria* are difficult to describe morphologically, they can be characterized using serological methods, and by their pathogenecity and specificity to certain species of domestic animals (Seifert, 1996). *Theileria species* are found throughout the world. *Theileria parva*, the most important member of the group occurs in East and central Africa. *Theileria annulata* another important member is found in the Mediterranean and sub-tropical regions of the old world. The occurrence of theileriosis and their epizootiological situation is not static especially in Africa. The theileriosis of greatest importance in veterinary medicine are the diseases caused in cattle by *T. parva, T. annulata, T. lawrenci* and *T. mutans* (Losos, 1986).

Ticks that are incriminated in the transmission of theleiriosis are: *Rh. appendiculatus, Rh. zambeziensis, Rh. bursa, Rh. pulchellus, Rh. e. evertsi,* and *Rh. s. simus.* Theileriosis caused by *T. mutans* is a mild form of disease characterized by pyrexia, anorexia and varying degree of anemia. This form is supposed to be present in Ethiopia as reported by Solomon (1994) and Temesgen (2003). It is transmitted by ticks of the genus *Amblyomma* and has until recently been considered benign but nowadays it has shown to be significantly pathogenic for cattle (Seifert, 1996).

3. MATERIALS AND METHODS

3.1. Study area

The study was conducted in Decha wereda, which is located at southwest part of the country. Decha is one of the largest wereda of Kaffa zone comprising 46 kebeles. It is bounded with Ginbo and Chenna weredas in the North; with Sheka zone to north-west; with South Omo zone in the South: Bench Maji zone in the West; Cheta, Telo, Menjiyo weredas and North Omo zone in the East (figure 1). It is situated 24 km from Bonga (The zonal capital). The altitudinal variation ranges from 800-2500 masl and is divided into three major agro ecological locations i.e. 7% Dega, 45% Woinadega and 48% Kola. It receives high rainfall (on average 145.96 mm yearly) providing for an essentially continuous growing period 330-360 days. Its annual average temperature ranges from 12.4°c –26.8 °c. The landscape is marked by the presence of undulating terrain. The vegetation until fairly recently it was covered by dense high forest; although the forest is now significantly destroyed, there remain substantial areas of forests mainly composed of bushes and broad leaved deciduous trees. Besides, woodlands and savanna grassland occurs in lowland areas. The wereda poses huge livestock resource, and according the report of CCACLP (2000) there were 79.064 cattle, 48.750 sheep, 17.159 goat, 3.037 horses, 1.605 mules, 125.714 poultry and 25.317 bee hives of local type.

Figure 1. Map showing the different zones of Southern Nations and Nationalities people's regional state and the area where the study took place.

3.2. Study design

3.2.1 Sample size determination and sampling methods

The epidemiological study of ixodid ticks and protozoal haemoparasites involved a single wereda, different peasant associations (PAs) and cattle as sampling unit. The wereda was selected purposively and the PAs were selected randomly from the total of each corresponding geographical zone i.e. highland, midland and lowland. The cattle were also selected randomly using systematic random sampling when they came for vaccination program. These were basically indigenous cattle breeds of *Bos indicus* managed under extensive production system. The classification of PAs into different geographical zones was made following the description of Sjoholm (1989), Annex 3.

3.2.1.1. Sample Size

The sample size for the study was determined using the formula indicated by (Pfeiffer, 2002), to determine or estimate the level of disease occurrence taking an estimated prevalence of tick infestation 88.2% indicated by Bekele (1987), accepted error of 5% and 95% confidence interval (CI). Formula used to calculate sample size to estimate or detect disease occurrence:

$$n = \frac{1.96^2 \, Pexp\,(1-P)}{d^2}$$

n – Required sample size

Pexp - expected prevalence

d - Desired absolute precision

Accordingly, a minimum of 153 cattle has to be sampled and for convenience we have added 7 cattle and sampled a total of 160 animals from each geographical zone. Further more, from the 160 animals, 40 animals were again selected randomly for longitudinal study. These animals were identified by their color, sex and using nylon strings by attaching tightly on their neck and also by their owners. They were not treated with any acaricide during the study period.

3.3. Study type

The study consisted of crossectional to determine the prevalence of ticks and tick-borne protozoal parasites and a controlled longitudinal study for seasonal variation of ticks as well as the protozoal diseases transmitted by them.

3.3.1. Observational study (cross-sectional study)

Estimation of prevalence of tick and tick-borne protozoal haemoparasites was made on 160 animals selected randomly from each geographical zone. Data such as the age and body condition of the animals was recorded prior to tick collection and blood sampling. The age of animals was determined following the description by FAO (1983) for zebu cattle where cattle without pair permanent incisor are estimated to be under two year, with the first pair of permanent incisor are estimated to be two year and three month old, with the second pair of permanent incisor are estimated to be three year old, with the third pair of permanent incisor are estimated to be three year and six month old and with the fourth pair of permanent incisor are estimated to be four year old. Old animals more than four years have 4 pairs of permanent incisor in wear.

The body condition of study animals was measured by visual inspection and palpation of the loin area and tail head of the animal. The degree of fatness over these areas is assessed, and a score of poor and good was given. The method of scoring is adapted from that described by Radostits and Blood (1985) by modifying the degree of fatness scored from 0 to 1 as POOR and degree of fatness scored from 2 to 4 as GOOD. The description of each score is shown in Annex 4.

3.3.2. Follow up seasonal study

A total of 120 cattle randomly selected from the three geographical zones were subjected to different study procedures such as determination of type and burden of tick species at different seasons of the year based on their age groups and body conditions. Thin blood smear were also made from these animals.

3.4. Study Methodology

3.4.1. Tick collection

Initially, half body tick collection was made on September from 160 randomly selected animals from each geographical zone for the determination of prevalence and later on following identification of the entire randomly selected animals (40 from 160 previously selected once) by using nylon strings, removal of feeding ticks from the animals was carried out at four different times (early and late rainy season i.e. March to April and September to October, early and late dry season i.e. November to December and January to February). Accordingly the first round sample was collected on September 2004 representing late rainy season (LRS), the second was sampled on November 2004 representing early dry season (EDS), the third round sample was taken in January 2005 which represent the late dry season (LDS) and finally, the fourth round sample was collected on March 2005, representing early rainy season (ERS).

After casting the animals down, half body tick collection was made on alternate body sides involving all visible attached adults, nymphs, and larvae of all tick species from eight (8) body regions (ear, head, dewlap, back, abdomen, udder/scrotum, ano-vulval and feet) as described by Kaiser *et al.* (1982). Tick samples from the individual animal were preserved in pre-labeled screw cap universal bottle containing 70% ethyl alcohol. Following counting and recording, the ticks were pooled into one bottle by body sites. Identification took place approximately within 10 days after collection has terminated using stereomicroscope and a guide for identification of African tick species (Hoogstraal, 1956 and Walker *et al.*, 2003) at Mizan regional laboratory (Bench Maji zone).

3.4.2. Blood smear examination

Thin blood smear were also prepared from the cattle under investigation which were then air dried, fixed in absolute methanol for 5 minute, stained with 10% Giemsa stain solution for 20-30 minutes, washed with tap water, dried and examined under oil immersion objective of compound microscope for the presence of tick-borne protozoa haemoparasites as described by Sloss *et al.* (1994).

3.5. Data Analysis

The number and kind of data required to determine analysis include those obtained from the ticks distribution, seasonal dynamics, burden and prevalence of protozoa haemoparasites. Microsoft Excel was used for data entry and management. Descriptive statistics such as percentage, standard deviation, mean, confidence interval (CI) were used to summarize the proportion of infested and non-infested animals. The effect of different epidemiological risk factors on prevalence of ticks was analyzed with logistic regression by entering all variables at ones. Analysis of variance (ANOVA) was used to test the effect of different risk factors on mean tick burden in different groups. The statistical analysis was made using Stata 7.0 and SPSS 2002 software and the significance level was determined at $p<0.05$ for all statistical tests.

4. RESULTS

A total of 4337 adult and immature ticks were collected from 480 animals for cross sectional study and 6459 adult and immature ticks were collected from 120 animals during four consecutive seasons for the purpose of longitudinal study.

4.1. Crossectional study findings

The result found in the present study shows that all examined cattle from lowland were positive for tick infestation followed by animals from midland and highland areas with 92.5% and 68.12% prevalence, respectively. Though the difference is not statistically significant between animals with different body conditions, the proportion of infested animals appear to be higher in animals of poor body condition (90.91%) than those in good body condition (85.16%). A significant variation ($p<0.05$) in prevalence of tick infestation was noted between different age groups, the highest being in animals of 3 and half and 4 years old, table1.

Table 1. Proportion of infested animals in different epidemiological risk factors.

Risk factor	No of animals examined	No of infested	Infestation rate (%)	Level of Significance
Agroecology				
Highland	160	109	68.12	P-value= 0.000 OR: 7.75
Midland	160	148	92.5	
Lowland	160	160	100	
Body condition				
Poor	143	130	90.91	P-value=0.151
Good	337	287	85.16	
Age group				
0-2 pair	128	95	74.22	P-value=0.000 OR: 2.1
3 & 4 pair	243	224	92.18	
> 4 pair	109	98	89.91	

Five tick species belonging to three genera (*Amblyomma, Boophilus and Rhipicephalus*) were identified. From the total tick count, the genus *Boophilus* represented the largest proportion (64.46%) in all altitudinal zones followed by *Amblyomma* (34.68%) and *Rhipicephalus* (0.85%). The most prevalent and abundant tick species was *B. decoloratus* (46.57 %) followed by *A. cohaerens* (22.53%) from the total count. Other tick species collected in small numbers were *A. lepidium* (1.15%), *R. praetextatus* and *R. e. evertsi* (0.14%). Immature ticks were also included in our collections representing a total amount of (28.89%) from the total count. There was no variation in genera and species type encountered in different altitudinal zones, however, significant difference was observed in terms of relative prevalence and abundance, table 2. The highest tick count was found in lowland areas (n=1869) followed by midland (n=1325) and highland (n=1143). Overall, *B. decoloratus* was mostly collected from lowland areas (55.11%) while *A. cohaerens* was predominant in midland geographical zones (30.87%).

Table 2. Relative abundance of tick species in different geographical zones.

Tick species	Study sites/ geographical zones			Overall prevalence (%)
	Highland	Midland	Lowland	
B. decoloratus	551 (48.21%)	439(33.13%)	1030 (55.11%)	2020 (46.57%)
*Boophilus spp.**	163(14.26%)	221(16.68%)	392 (20.97%)	776 (17.89%)
A. cohaerens	314(27.47%)	409(30.87%)	254 (13.59%)	977 (22.53%)
A. lepidium	0	36(2.72%)	14 (0.75%)	50 (1.15%)
*Amblyomma spp**	101(8.84%)	206(15.55%)	170 (9.09%)	477 (11%)
R. praetextatus	11(0.96%)	12(0.91%)	8(0.43%)	31 (0.71%)
R. e. evertsi	3(0.26%)	2(0.15%)	1(0.05%)	6 (0.14%)
Ttotal	1143 (26.35%)	1325 (30.55%)	1869 (43.1%)	100%

* immature

The highest mean tick burden was found in lowland animals (11.68 ticks), in animals with poor body condition (13.34 ticks) and in those animals having 3 and half and 4 years old, (10.55 ticks), Figures 2,3,4. This variation in mean tick burden has shown significant difference for all tested epidemiological risk factors ($p<0.05$), Annex 5. In pair wise comparisons, statistically significant difference ($p<0.05$) was obtained between animals of different body conditions. No significant difference ($p>0.05$) was noted between animals of older age groups i.e. between those of more than 4 years old and those having 3 and half and 4 years old. Similarly there was no significance between highland and midland geographical zones, Annex 6.

Figure 2. Mean tick burden in different geographical zones.

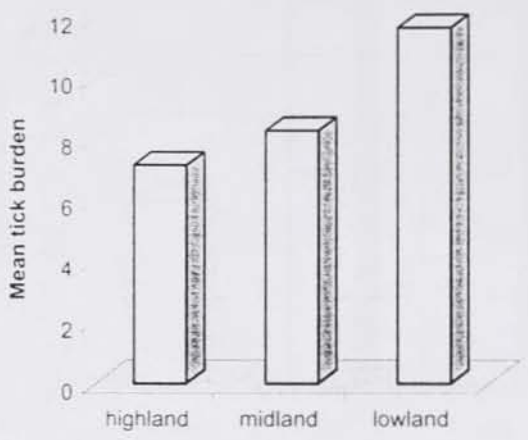


Figure 3. Mean tick burden in different body conditions.

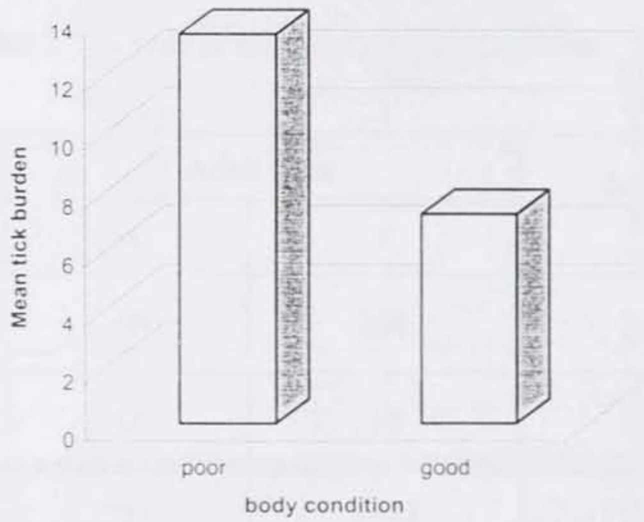
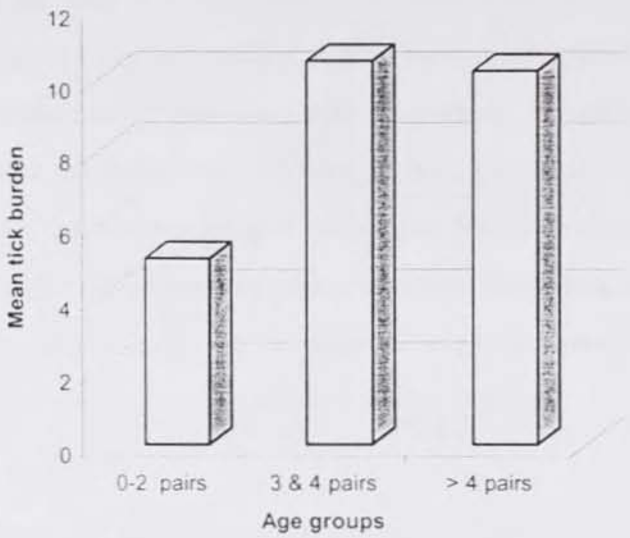


Figure 4. Mean tick burden in different age groups.



Out of the whole tick population collected, the proportion of female adult ticks was higher than adult males; male to female ratio was greatest in species of genus *Amblyomma* and *R. e. evertsi* while for *B. decoloratus* and *R. praetextatus* females adult ticks were found to be higher, table 3.

Table 3. Sex ratio in different adult tick species.

Species	Adult ticks		Sex ratio M: F
	M	F	
A. cohaerens	709	268	2.64:1
A. lepidium	32	18	1.78:1
B. decoloratus	597	1423	0.42:1
R. praetextatus	6	25	0.24:1
R. e. evertsi	4	2	2:1

4.1.1. *Distribution of ticks by attachment site*

The distribution of tick species at eight different attachment sites as measurement of their preference is illustrated on table 4. Even though, *B. decoloratus* was virtually found all over the body, it predominates mainly on dewlap, back, belly and udder/scrotum body sites; *A. cohaerens* showed preference to the belly and udder/scrotum; *A. lepidium* has showed affinity as same as *A. cohaerens* on belly and udder/scrotum. Immature *Boophilus spp.* showed affinity mainly to dewlap, udder/scrotum and belly area while immature of *Amblyomma spp.* showed slight preference for attachment to udder/scrotum, belly and dewlap body sites. Both *Rhipicephalus spp. (R. praetextatus & R evertsi evertsi)* have shown preference for attachment to belly, udder/scrotum and ano-vulval body regions.

Table 4. Distribution of tick species on selected body sites for attachment.

of hm t	Tick species recovered from different geographical zones													
	n=2018	B.d (%)	n=977	A.c (%)	n=50	A. l (%)	n=35	R p (%)	n=6	R.e.e. (%)	n=477	A. spp (%)	n=774	B. spp (%)
r	131	6.49	16	1.64	0	-	8	5.71	0	-	43	9.01	82	10.59
ad	193	9.56	16	1.64	1	2	1	2.86	0	-	33	6.92	54	6.98
lap	682	33.79	68	6.96	2	4	2	5.71	0	-	79	16.56	245	31.65
ck	373	18.48	44	4.5	1	2	1	2.86	0	-	35	7.34	91	11.76
ly	263	13.03	328	33.57	10	20	1	2.86	1	16.67	110	23.06	124	16.02
er/s um	280	13.87	455	46.57	36	72	7	20	3	50	141	29.56	128	16.54
o- val	66	3.27	45	0.22	0	-	16	45.71	2	33.33	27	5.66	45	5.81
et	30	1.49	5	0.51	0	-	1	2.86	0	-	9	1.89	5	0.64

Key

B. d---- *Boophilus decoloratus*
A. spp—*Amblyomma species* (immature)
B. spp—*Boophilus species* (immature)
R. p---- *Rhipicepalus praetextatus*
R. e. e—*Rhipicephalus e. evertsi*
A. c---- *Amblyomma cohaerens*
A. l---- *A. lepidium*

4.2. Longitudinal study

A total of 6459 adult and immature ticks were collected from 120 randomly selected animals (40 animals/stratum) that were sampled consecutively for four different seasons and the over all findings are summarized in table 5 below.

Table 5. Proportion of infested animals in different epidemiological risk factors.

Risk factor	No of animals examined	No of infested	Infestation rate (%)	Level of Significance
Season				
Early rainy	109	107	98.16	P-value=0.892
Late rainy	120	102	85	
Early dry	120	106	88.33	
Late dry	110	106	96.36	
Geographical zones				
Highland	152	124	81.58	P-value=0.000 OR=3.03
Midland	152	148	97.37	
Lowland	155	149	96.13	
Age group				
0-2 pair	114	100	87.72	P value=0.391
3 & 4 pair	197	186	94.42	
> 4 pair	148	135	91.22	
Body condition				
Poor	186	174	93.55	P-value=0.244
Good	273	247	90.48	

The proportion of infested animals in different seasons and other risk factors appears to be statistically non significant ($p>0.05$) except for geographical zones (OR=3.03 $p=0.000$). However, there was some degree of variation in the proportion of infested animals within different risk factors. As shown in table 5 above, the highest proportion of infested animals was detected during early rainy season (98.16%), in midland geographical zone (97.37%), in animals of 3 and half years and 4 years old (94.42%) and in those of poor body condition (93.55%).

Six different tick species belonging to four genera namely *Boophilus*, *Amblyomma*, *Rhipicephalus*, and *Haemaphysalis* were identified. The genus *Boophilus* was the most abundant genus (54.14%) followed by *Amblyomma* (45.1 %) and *Rhipicephalus* (0.72%) from the total count. The genus recovered with small number was *Haemaphysalis* representing (0.03%). This hierarchical status of different genera is maintained in favor of *Boophilus* in all seasons and altitudinal zones except in lowland, which is dominated by *Amblyomma* (54.03%). *Boophilus decoloratus* was the most abundant tick species found in all geographical zones and seasons accounting for 31.54% from the total count. It has been recorded in large numbers from highland altitude (33.63%) and early rain season (34.93%) i.e. March to April. *Amblyomma cohaerens* is the next abundantly collected tick species, which have got 26.09% from the total count and predominating mostly in lowland altitude (39.06%) more than that of *B. docoloratus* and in early rainy season (30.62%) i.e. March to April.

Table 6. Relative abundance of ixodid ticks in different geographical zones.

Species	Highland	Midland	Lowland	Overall Prevalence (%)
B. decoloratus	672 (33.63%)	961 (29.73%)	404 (32.87%)	2037 (31.54%)
*Boophilus spp.**	656 (32.83%)	654 (20.23%)	150 (12.20%)	1460 (22.6%)
A. cohaerens	357 (17.87%)	848 (26.24%)	480 (39.06%)	1685 (26.09%)
Amblyomma * *spp.*	289 (14.46%)	674 (20.85%)	150 (12.20%)	1113 (17.23%)
A. lepidium	14 (0.70%)	67 (2.07%)	34 (2.77%)	115 (1.78%)
R. praetextatus	7 (0.35%)	24 (0.74%)	10 (0.81%)	41 (0.63%)
R. e. evertsi	3 (0.15%)	2 (0.06%)	1 (0.08%)	6 (0.09%)
H. aciculifer	0	2 (0.06%)	0	2 (0.03%)
Total	1998 (30.93%)	3232 (50.04%)	1229 (19.03%)	100%

Important figures were also obtained on immature ticks (*Boophilus spp. and Amblyomma spp.)*. The highest number of the former group was recorded in highland geographical zones (32.83%) and in late rainy season (36.49%), while for the later group midland altitude (20.85%) and late dry season (21.38%). In spite of few collections made during the study period, *A. lepidium* has been recorded at the highest level in lowland altitudes (2.77%) and early dry season (3.85%). *Rhipicephalus praetextatus* and *R. e. evertsi* collectively have been found in large number in late dry season and middle altitude even though there were very few collections. Only two *H. aciculifer* tick species were found and these were recovered from midland during early and late rainy seasons.

Table 7. Relative abundance of ixodid ticks in different seasons.

Species	Early rainy	Late rainy	Early dry	Late dry	Overall Prevalence (%)
B. decoloratus	802 (34.93%)	344 (29.6%)	500 (29.15%)	391 (30.40%)	2037 (31.54%)
*Boophilus spp.**	351 (15.29%)	424 (36.49%)	433 (25.25%)	252 (19.59%)	1460 (22.6%)
A. cohaerens	703 (30.62%)	208 (17.90%)	459 (26.76%)	315 (24.49%)	1685 (26.09%)
*Amblyomma spp.**	411 (17.90%)	176 (15.15%)	251 (14.63%)	275 (21.38%)	1113 (17.23%)
A. lepidium	21 (0.91%)	6 (0.52%)	66 3.85%)	22 (1.71%)	115 1.78%)
R.praetextatus	7 (0.30%)	3 (0.26%)	6 (0.35%)	25 (1.94%)	41 (0.63%)
R. e. evertsi	0	0	0	6 (0.47%)	6 (0.09%)
H. aciculifer	1 (0.04%)	1 (0.09%)	0	0	2 (0.03%)
Total	2296 (35.55%)	1162 (17.99%)	1715 (26.55%)	1286 (19.91%)	100%

* immature

Result of estimates of mean tick burden for different measurable parameters indicates that except between different age groups, there is significant difference in between different geographical zones, season and body condition ($p<0.05$). The mean tick burden is significantly higher in midland altitudes (22.986 ticks), early rainy season (20.713 ticks), and in those animals with poor body condition (19.532 ticks) Annex 7. Pair wise comparisons on mean tick burden within different risk factors has shown results of varying degree i.e. midland compared to high and lowland zones showed significant difference Annex 8. No difference was observed between different age groups. The total number and relative abundance of ixodid ticks collected in different geographical zones and seasons are summarized in table 6 and 7 respectively. The highest ticks were recovered in early rainy season (n=2296) and midland altitude (n=3232). In longitudinal observation unlike to the cross sectional, male adult ticks were collected in large number than the females from the various geographical zones and seasons. Generally the male to female ratio appears to be (1.04:1), this ratio is consistent in species of the genus *Amblyomma* but not in *B. decoloratus* in which males of this particular species are scanty in number table 8.

Table 8. Sex ratio of adult tick species in different season.

Species	Season	Adult ticks		Sex ratio
		M	F	M: F
A. cohaerens	Early rainy	556	146	3.81:1
A. lepidium	" "	11	10	1.1:1
B. decoloratus	" "	184	618	0.3:1
R. praetextatus	" "	0	7	-
H. aciculifer	" "	1	0	-
A. cohaerens	Late rainy	177	32	5.5:1
A. lepidium	" "	3	3	1:1
B. decoloratus	" "	75	271	0.28:1
R. praetextatus	" "	0	3	-
H. aciculifer	" "	1	0	-
A. cohaerens	Early dry	363	96	3.78:1
A. lepidium	" "	55	11	5:1
B. decoloratus	" "	156	334	0.45:1
R. praetextatus	" "	2	4	0.5:1
A. cohaerens	Late dry	253	62	4.08:1
A. lepidium	" "	16	7	2.28:1
B. decoloratus	" "	121	270	0.45:1
R. praetextatus	" "	4	21	0.19:1

4.3. Results of blood examination

Although attempts to detect tick-borne protozoal hemoparasites was not successful, laboratory result of thin blood smear indicates that out of 480 sampled animals during the first part of study 35 (7.29%) were found to be infected with different *Trypanosoma species* and except a single animal from midland almost all of them were from lowland areas accounting for overall prevalence of 7.08%. During the longitudinal, like in the cross sectional, no clinical cases of tick-borne protozoal diseases were encountered in the study area. However, microscopic investigation of thin blood smear revealed 53 positive animals for trypanosome blood parasites from a total of 120 animals that were under repeated observation in different seasons. The observation was statistically significant ($p<0.05$) in different geographical zone and seasons, the highest prevalence was encountered in early rainy season i.e. March to April. A significant difference ($P<0.05$) among geographical zones was observed the highest being in lowland. *Trypanosoma congolense* was the dominant trypanosome species in the area.

5. DISCUSSION

5.1. Type and prevalence of tick species

Both cross sectional and longitudinal studies conducted disclosed the high prevalence of tick infestation in the study area particularly in lowlands and midlands and the comparatively low prevalence of tick infestation in highland geographical zones. Almost all in lowland and some times in midlands, 100% of the animals harbor at least one or more tick species. A similar high prevalence of tick infestation has been reported in cattle of Ethiopia by (Mohamed, 1985; Bekele, 1987 and Tedla, 1991). The increased prevalence obtained in lowland as well as in midland cattle is probably attributed to the existing favorable microclimatic conditions induced by the intermittent rainfall that these areas have received during the study period combined with relatively higher temperature, which is suitable for tick development. Three genera and five tick species which include *B. decoloratus, A. cohaerens, A. lepidium, R. praetextatus* and *R. e. evertsi* were found both during cross-sectional and longitudinal study and an additional *H. aciculifer* was recovered during the longitudinal study. Different researchers, particularly those who have worked in the Southwest part of the country reported that these are common and abundant tick species of cattle in the area; Seleshi *et al.* (1992) and De Castro (1994) from Southwestern zones; Kassaye (1994) & Yitbarek (2004) from Jimma; Teshome *et al.* (1995) and Seid (2004) from Mizan Teferi.

In the present study, *B. decoloratus* was the most predominant tick species accounting for 46.57% and 31.54% from the total count during cross sectional and longitudinal observations, respectively. It has often been found evenly distributed in all geographical zones and almost with the same pattern in different seasons; however it is mainly recorded in low and highland zones and in early rainy season i.e. March to April. Teshome *et al.* (1995) achieved comparable results where *Boophilus decoloratus* was abundantly found at Holeta with a share of more than 80% of the count, according to them *B. decoloratus* has dominated the tick fauna picture throughout the year. The widespread distribution and high prevalence of this tick species has also been reported by various researchers (Bekele, 1987; Manueri and Tilahun, 1991; Kassaye, 1994; Behailu, 2004; Yitbarek, 2004). In early studies, Hoogstraal (1956) described the wide distribution of *B. decoloratus* throughout most of the Ethiopian faunal region currently known as Afrotropical zoogeographical region, within its range it occurs everywhere except in more open dry areas and in tropical forests. Again Morel (1980) ratified that this species is Ethiopian proper and its distribution only concerns tropical Africa. Because of its parasitic importance it has been quoted on cattle in many instances. He added that it might naturally infest wild ungulates on parts of its distributional area, mainly ruminants less commonly carnivorous mammals. Concerning to immature of *Boophilus* ticks our finding reveals that they were predominating in number as compared to *Amblyomma* in both study types accounting for an overall prevalence of 53.80%. These were widely distributed in all study sites with peak number in highland (32.83%) and in late rainy season i.e. September to October (36.49%), the low count on the other hand was observed in lowland (12.20%) and early rain season i.e. March to April (15.29%). In contrast to this, Yitbarek (2004) has found immature *Amblyomma* ticks in high quantity (72.9%) followed by *Boophilus* (24%) and *Rhipicephalus* (3.1%) out of 1215 immature ticks. This could probable be attributed to variation in the area and season of the study.

With regard to the prevalence of *A. cohaerens*, which is the second common tick species was found predominating in midland areas during the cross sectional study (30.87%) while in the longitudinal study it was recovered in great number from lowland areas (39.06%) in early rain season (30.62%) i.e. March to April. Similarly, Zelalem (2003) also recorded this tick species to be the second common tick species at Ghibe ILRI/ EARO research station next to *B. decoloratus*. Tedla (1991) in his study has found this species at higher proportion in highlands than lowland areas. Other researchers have collected it in small number and in specific places (Manueri and Tilahun 1991; Teshome *et al.*, 1995). Bekele (1987) in his study at Illubabor found *A. cohaerens* as a predominant tick species in highland and midland geographical zones. According to Morel (1980) this species is a specific parasite of the Buffalo in African savanna. It looks more particularly connected with *Syncerus caffer aequinoctialis subspecies*, but it subsists normally in cattle where there is no initial host or when it has disappeared. In Ethiopia, its collection coincides as the whole with dense formation of mountain subtropical grassland (Morel, 1980).

In the present study, the highest number of *A. lepidium* was recovered from lowland altitudes (2.77%) and in early dry season (3.85%). According to Manueri and Tilahun (1991), *Amblyomma lepidium* was found numerically less in highland collection sites; highest numbers was found in lowland areas (Shinille). Seid (2004) collected in area with an altitude in between 1100 m to 1270 masl that corroborate our findings. Similarly, Hoogstraal (1956), Seleshi *et al.* (1992) and De Castro (1994) reported this species as common and abundant in lowland areas. Yitbarek (2004) has found immature *Amblyomma* ticks in high quantity (72.9%) followed by *Boophilus* (24%) and *Rhipicephalus* (3.1%) out of 1215 immature ticks.

5.2. Effect of season on tick burden and prevalence

Though statistical variations were not observed in the proportion of infested animals of the present study, greater numbers of infested animals 98.16% and 35.54% of the whole tick count were found in early rain season i.e. March to April. According to Abebaw (2004) high humidity and temperature are crucial factors that influence the seasonal variation of ticks. Solomon *et al.* (2003) mentioned that the prevalence rate and intensity of infestation were generally low during the dry season and higher in rainy season. The absence of statistical significance obtained in our study might be attributed partly to the continuous rainfall pattern that the region has received during the study period, which enables the tick population to proliferate and maintain their reproductive capability every time.

The cycle of seasons determines the alternation of appearance, reduction, and disappearance of ticks thus; at the end of rainy season there is a marked decrease with a progressive fall to almost zero in dry season (Morel, 1989). Although different species have different microclimate requirement, as a general rule tick activity is adjusted so that tick reproduction is greatest during the rain season. Hunter (1994) describes the importance of rainfall as limiting factor in tropical and subtropical climates where temperature is suitable for tick activity. Dry environmental conditions are a serious danger to ticks particularly to the questing larvae, which are very susceptible to drying out fatally (Walker *et al.*, 2003).

In our collection, the highest number of *B. decoloratus* was recovered in early rainy season representing 34.93%. Etsay (1985) found a rise in the number of *Boophilus* that coincides with the increment in the pattern of rainfall. Morel (1989) based on the effect of environment states that parasitism is reduced during the dry months (March-June north of the equator) and increases sharply within days following the first major winter rainfall. Dreyer *et al.* (1998) also found significantly higher numbers of *B. decoloratus* in autumn and winter (March to May and June to August) compared to spring and summer (September to November and December to March) with 76.8% of the total tick burden occurring during the cooler months. De Castro (1994) observed that in localities with rain most of the year; *B. decoloratus* females were abundant from September to April end of rainfall peak to beginning of the next rain season. In the present study, females of *B. decoloratus* were found in great number as compared to males in all study sites and seasons with a significant increment in proportion during the early rainy season i.e. March to April, a finding that concord with the findings of De Castro (1994). This result is also in agreement with the findings reported by Manueri and Tilahun (1991); Solomon *et al.* (2003); Yitbarek (2004) and Seid (2004). This might have resulted probably because of the small size of male *B. decoloratus* that can be overlooked during counting and identification. The seasonal occurrence of immature ticks was also considered where in study conducted by Seid (2004) higher count of immature *Boophilus* was recovered in December (28.31%) and a low count was recorded in March (20.19%). De Castro (1994) reported that nymphs of *B. decoloratus* were collected during March to April and October to November beginning and end of the rain respectively. In the present study highest count of immature ticks was made during early rainy season 52.83% from the total count. Nevertheless, highest record for immature of *Boophilus* was made in late rainy season (36.49%) i.e. September to October.

Amblyomma cohaerens was found mostly during early rain (30.62%) and early dry seasons (26.76%) i.e. March to April and November to December, respectively but this numerical variation however was not statistically significant in between different seasons. In a survey conducted by Behailu (2004) this species was relatively common during collections around December (A period that coincide immediately after rainy season). They were absent from collections around February and early March. *A. lepidium* was the least recovered tick in all study sites. The highest number was recovered in early dry season (3.85%) i.e. November to December during longitudinal study. Morel (1980) considers this species as less abundant but common overlapping with *A. gemma* in the driest and with *A. variegatum* in the wettest habitats. In our study immature of *Amblyomma* ticks were likely found during the dry season (21.38%) i.e. January to February. Seid (2004) has found higher proportion of immature *Amblyomma* ticks in November (41, 94%) and lower proportion was seen in February (22.81%). According to his study, the proportion of immature *Amblyomma* was reduced as the season relatively changes from wetter to drier.

5.3. Effect of body condition and age on tick prevalence

In both study types although no statistical significance was found in different body conditions ($P>0.05$), highest prevalence of tick infestation was observed in animals with poor body condition and in those animals of 3 year & six month and more than 4 years old. Seid (2004) found that tick burden on cattle in poor body condition was higher (an average of 22.49 tick per animal) than cattle in good body condition (an average of 17.76 ticks per animal). In contrast to this finding, Tesfanesh (1993) stated that age, sex, and breed differences of the host did not affect or influence the burden and species of ticks, she however explains that cattle in the adult age and having poor body condition were seen infested with large number of ticks. Onen *et al.* (1999) confirmed that generally more ticks were observed on cows than calves, very low tick counts were observed on calves aged 0-6 months than the other age groups. Seyourn (2001) found that the number of ticks attached to animals increases with their age. The difference on tick burden in different age groups may be associated to grazing practices since in almost all part of the country young animals do not go to pasture for grazing so they become less infested than the older ones.

Calves are less attractive to ticks than cows because they are protected by some form of innate, age related resistance, since host seeking activity involves awaiting hosts in an environment in advantageous positions on vegetation, they have greater chances of attaching on cows than calves because of body surface area (Onen *et al.*, 1999). It is also possible that these differences may be attributed to continuous selective grooming of calves' heads, ears, and necks by their respective dams (Fivas and De Waal, 1993). In the case of animals with poor body condition the situation might be associated to managemental and nutritional condition. For example, general malnutrition can cause reduce disease resistance by altering immune responses and a depressed immune system, in turn causes increase susceptibility to disease, reduce immunological response to vaccines, and non responsive to medical therapy (Radostits, 2001).

6. CONCLUTIONS AND RECOMMENDATIONS

The present study clearly demonstrated that highest proportion of animals were infested in midland and lowland areas and high tick burden was found during the early rainy season i.e. March to April indicating the direct role of rainfall in the distribution and population density of ticks. Although a large number and different species of ticks were collected, and a remarkable number of cattle found to be infested with ticks in both study types, tick-borne protozoal parasites were not detected both clinically and at blood smear examination. It is therefore important to understand that in a situation like ours it has been suggested that enzootic stability might have established, which according to different authors is desirable and economically acceptable as the condition eliminates outbreak of diseases.

On the other hand, ticks are important not only because of disease transmission but also they are excellent blood feeders leading to anemia, cause mechanical or cytolitic effect, they are responsible also for different conditions associated with toxins they produce etc. The current attempt by the government to improve the blood levels of the local animals through artificial insemination and distribution of improved cattle breeds to farmers should take into consideration the widespread existence of tick in the area, and the susceptibility of exotic or crossbred animals to tick and tick-borne diseases. Further, the unrestricted movement of cattle from place to place coupled with the closeness and climatic similarities of the study area to countries like Kenya and Sudan with potential disease entities makes the area as well as the country in a situation continuously threatened by different tick and tick borne diseases particularly of East Coast Fever caused by *Theileria parva* and its vector *R. appendiculatus*. Based on the present finding and the special concern of tick and tick-borne disease in the area the following recommendations are made:

- ✓ Application of acaricides particularly during early rainy seasons inducing the tick population to manageable level i.e. to the extent without affecting the enzootic stability.

- ✓ Restriction of movement of cattle and quarantine measures especially from marginal or bordering areas into the country should be exercised.

- ✓ Creation of awareness among livestock owners on the potential effect of tick and tick-borne diseases and on means of improving the traditional management system in general and the nutritional status of their animals in particular should be made.

- ✓ A more detailed and year round epidemiological study and a constant surveillance of tick and tick-borne diseases are required using more sensitive diagnostic techniques such as serology.

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8. ANNEXES

Annex 1. Existing tick species in different regions.

Region	Genera and Species					Source
	Amblyomma	*Boophilus*	*Rhipicephalus*	*Hyalomma*	*Haemaphysalis*	
SNNPRS	*A. variegatum* *A. gemma* *A. lepidium* *A. cohaerens*	*B.decoloratus*	*Rh. pulchellus* *Rh. appendiculatus?* *Rh. e. evertsi* *Rh. pravus* *Rh. s. simus?* *Rh. bergeoni* *Rh. practextatus* *Rh. sanguineous*	*H. truncatum* *H. marginatum* *H. albiparmatum* *H. dromedarii* *H. m. rufipes*		Jewaro (1986) Sebsibe (1988) Mohammed (1985) Tesfanesh (1993)
Amhara	*A.variegatum* *A. lepidium*	*B. decoloratus*	*Rh. pulchellus* *Rh .e. evertsi* *Rh .s. simus?* *Rh. lunulatus* *Rh. pravus* *Rh. sanguineous* *Rh. bergeoni* *Rh. praetextatus*	*H.a. excavatum* *H. m. rufipes* *H. dromedarii* *H. impeltatum*	Hae. aciculifer Hae. parmata	Eshetu (1986) Eshetu (1988) Mesele (1989)
Oromiya	*A. variegatum* *A. cohaerens* *A. gemma* *A. lepidium*	*B. decoloratus* *B. annulatus?*	*Rhipicaphalus spp.* *Rh .e. evertsi* *Rh. s. simus?* *Rh pulchellus* *Rh. praetextatus*	*Hyalomma spp.* *H. truncatum* *H. m.rufipes*		Dejenu (1988) Tadele (1989) Belete (1987) Bekele (1987) Solomon *et al.* (2003) Wallaga (1997) Temesegen (2003) Tedla (1991)
Tigray	*A. variegatum* *A. lepidium* *Amblyomma spp.*	*Boophilus spp.* *B. decoloratus*	*Rh. e. evertsi* *Rh. s. simus?* *Rh. pulchellus* *Rh. praetextatus* *Rhipicephalus spp.*	*Hyalomma spp.* *H. truncatum* *H. m. rufipes*		Hagos and Markos (2003) Surafel (1996)
Harari	*A .variegatum* *A cohaerens* *A gemma* *A. lepidium*	*B. decoloratus*	*Rh. pulchellus* *Rh. e. evertsi* *Rh simus simus?* *Rh. sanguineus*	*H. dromedarii* *H. rufipes* *H. truncatum* *H. impeltatum*		Gulilat (1987)

Annex 2. Ticks reported from different ranches and research centers of Ethiopia.

Research center	Genera and species					Source
	Amblyomma	*Boophilus*	*Rhipicephalus*	*Hyalomma*	*Haemaphysalis*	
Abernosa ranch	*A.variegatum*	*B.decoloratus*	*R. e. evertsi*	*H. m. rufipes*		Solomon (1993)
Didtuyura	*A.variegatum* *A. gemma*	*B.decoloratus*	*R. pulchellus*			Solomon (1994)
Bako research center	*A. cohaerens* *A.variegatum*	*B.decolaratus*	*R. e. evertsi*			Teshome (1985)
Metekel ranch	*A.variegatum*	*B.decoloratus*	*R. e. evertsi* *R. s. simus ?*	*H. m. rufipes*		Alekaw (2000)
Jimma state farm	*A. cohaerens*	*B.decoloratus*	*R. e. evertsi*			Kassaye (1994)
Ghibe ILRI (low land)	*A. vaiegatum* *A. cohaerens*	*B.decoloratus* *Boophilus spp.*	*Rhipicephalus spp.* *R.e.evertsi* *R. bergeoni* *R. lunulatus* *R. muhsamae* *R. pravus* *R. simus?*	*H.m. rufipes*	*Hae. aciculifer*	Adey (2004); Zelalem (2003)

Annex 3. Agroclimatic zones of Ethiopia.

Altitude in meters above sea level (masl)				
> 3700				**High wurch** (No community forestry) A: None (frost limit) C: None S: Blacksoils, highly degraded T: Mountain grass land
3200 to 3700			**Moist wurch** A: Only Barley, one cropping season per year C: Drainage rare S: Black soils, degraded T: Erica, Hypericum	**Wet wurch** A: Only Barley, two cropping season per year C: Widespread drainage ditches S: Black soils, highly degraded T: Erica, Hypericum
2300 to 3200			**Moist Dega** A: Barley, wheat and pulses, one cropping season per year C: Some trad, terracing S: Brown clay soils T: Jeniperus, Hagenia, Podocarpus	**Wet dega** A: Barley, Wheat, Nug, Pulses, two cropping season per year C: Drainage ditches widespread S: Dark brown clay soils T: Jeniperus, Hagenia, Podocarpus, Bamboo
1500 to 2300		**Dry Weynadega** A: Wheat, Tef, rarely Maize C: Terracing widespread S: Light brown to yellow soils T: Acacia trees	**Moist Weynadega** A: Maize, Sorghum, Tef, Inset rare, Wheat, Nug, Dagussa, Barley C: Trad, terracing S: Red brown soils T: Acacia, Cordia, Ficus	**Wet Weynadega** A: Tef, Maize, Inset in W parts, Nug, Barley C: Drainage widespread S: Red clay soils, deeply weathered, gullies frequent T: Many varieties, Ficus, Cordia, Acacia, Bamboo
500 to 1500		**Dry kolla** A: Sorghum rare, tef C: water retention terraces S: Yellow sandy soils T: Acacia bushes and trees	**Moist Kolla** A: Sorghum, rarely tef, nug, dagussa, ground nut C: Terracing widespread S: Yellow silty soils T: Acacia, Erithrina, Cordia, Ficus	
< 500		**Bereha** (No community forestry) A: none except irrigation areas C: none S: yellow sandy soil T: acacia bushes		
		< 900	900 to 1400	> 1400
		Annual rainfall (millimeters)		

LEGEND:

A: Main crop
C: Traditional conservation
S: Soils on slopes
T: Natural trees

Annex 4. Scores for measurement of body condition adapted from Radostits and Blood, (1985).

0 No fatty tissue is felt, shape of transverse processes clearly visible, deep cavity under tail and around tail head. Animal appears emaciated.

1 Deep depression in loin, ends of transverse process sharp to touch and upper surfaces can be felt easily, cavity present around tail head.

2 Some fatty tissue felt under the skin, pelvis felt easily, ends of transverse processes feel rounded and upper surfaces felt only with pressure, visible depression in the loin.

3 Fatty tissue easily felt over the whole area, skin appears smooth, slight depression visible in loin; end of transverse processes can be felt with pressure, but tick layers of tissue on top.

4 Transverse processes can not be felt even with firm pressure, no depression visible in loin between back bone and hip bones, patches of fat apparent under the skin, pelvis felt only with firm pressure.

Annex 5. Mean tick burden difference in different epidemiological risk factors during the cross-sectional study.

a) In different geographical zones.

Descriptives

SUM

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Highland	160	7.14	10.820	.855	5.45	8.83
Midland	160	8.28	8.990	.711	6.88	9.68
Lowland	160	11.68	8.755	.692	10.31	13.05
Total	480	9.04	9.740	.445	8.16	9.91

ANOVA

SUM

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1783.617	2	891.808	9.744	.000
Within Groups	43654.781	477	91.519		
Total	45438.398	479			

b) In different age groups.

Descriptives

SUM

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
0-2 pair	128	5.10	6.762	.598	3.92	6.28
3 & 4 pair	243	10.55	10.337	.663	9.25	11.86
> 4 pair	109	10.28	10.122	.970	8.35	12.20
Total	480	9.04	9.740	.445	8.16	9.91

ANOVA

SUM

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2706.868	2	1353.434	15.108	.000
Within Groups	42731.530	477	89.584		
Total	45438.398	479			

c) In animals having different body conditions.

Descriptives

SUM

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Poor	144	13.34	11.664	.972	11.42	15.26
Good	336	7.19	8.135	.444	6.32	8.06
Total	480	9.04	9.740	.445	8.16	9.91

ANOVA

SUM

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3812.262	1	3812.262	43.777	.000
Within Groups	41626.136	478	87.084		
Total	45438.398	479			

Annex 6. Pair wise comparisons on tick burden in between different risk factors that were considered in cross-sectional study.

a) **In between different geographical zones.**

Dependent Variable: SUM

(I) Geo. Zone	(J) Geo. Zone	Mean Difference (I-J)	Std. Error	Sig.(a)	95% Confidence Interval for Difference (a)	
					Lower Bound	Upper Bound
Highland	Midland	-1.568	1.163	.178	-3.854	.717
	Lowland	-4.655	1.428	.001	-7.460	-1.849
Midland	Highland	1.568	1.163	.178	-.717	3.854
	Lowland	-3.086	1.428	.031	-5.893	-.279
Lowland	Highland	4.655	1.428	.001	1.849	7.460
	Midland	3.086	1.428	.031	.279	5.893

The mean difference is significant at the .05 level.

Univariate tests

Dependent Variable: SUM

	Sum of Squares	df	Mean Square	F	Sig.
Contrast	838.332	2	419.166	5.314	.005
Error	36518.504	463	78.874		

The F tests the effect of Geo. Zone. This test is based on the linearly independent pair wise comparisons among the estimated marginal means.

b) In between animals of different age groups.

Dependent Variable: SUM

(I) AGE	(J) AGE	Mean Difference (I-J)	Std. Error	Sig.(a)	95% Confidence Interval for Difference(a)	
					Lower Bound	Upper Bound
0-2 pair	3 & 4 pair	-6.039	1.387	.000	-8.765	-3.312
	> 4 pair	-5.403	1.485	.000	-8.322	-2.484
3 & 4 pair	0-2 pair	6.039	1.387	.000	3.312	8.765
	> 4 pair	.635	1.151	.581	-1.627	2.898
> 4 pair	0-2 pair	5.403	1.485	.000	2.484	8.322
	3 & 4 pair	-.635	1.151	.581	-2.898	1.627

* The mean difference is significant at the .05 level.

Univariate tests

Dependent Variable: SUM

	Sum of Squares	df	Mean Square	F	Sig.
Contrast	1561.050	2	780.525	9.896	.000
Error	36518.504	463	78.874		

The F tests the effect of AGE. This test is based on the linearly independent pair wise comparisons among the estimated marginal means.

b) In between animals of different body conditions.

Dependent Variable: SUM

(I) Body con.	(J) Body con.	Mean Difference (I-J)	Std. Error	Sig.(a)	95% Confidence Interval for Difference(a)	
					Lower Bound	Upper Bound
1	2	5.030	1.080	.000	2.908	7.152
2	1	-5.030	1.080	.000	-7.152	-2.908

The mean difference is significant at the .05 level.

Univariate tests

Dependent Variable: SUM

	Sum of Squares	df	Mean Square	F	Sig.
Contrast	1712.010	1	1712.010	21.706	.000
Error	36518.504	463	78.874		

The F tests the effect of Body con.. This test is based on the linearly independent pair wise comparisons among the estimated marginal means.

Annex 7. Estimates of mean tick burden and confidence interval in different measurable parameters in longitudinal study.

a) Mean tick burden on different geographical zones.

Estimates

Dependent Variable: SUM

Geo. Zone	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Highland	11.255	1.555	8.198	14.312
Midland	22.986	1.489	20.058	25.914
Lowland	7.992(a)	2.101	3.862	12.122

a Based on modified population marginal mean

b) Mean tick burden on different seasons.

Estimates

Dependent Variable: SUM

SEASON	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Early rainy	20.713(a)	2.034	16.715	24.711
Late rainy	9.054(a)	1.788	5.539	12.569
Early dry	18.805(a)	1.787	15.291	22.318
Late dry	10.781(a)	2.078	6.697	14.866

a Based on modified population marginal mean.

c) Mean tick burden on different age groups.

Estimates

Dependent Variable: SUM

AGE	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
0-2 pair	12.984(a)	1.636	9.768	16.201
3-4 pair	14.355	1.641	11.128	17.581
> 4 pair	16.558	1.648	13.320	19.797

a Based on modified population marginal mean.

d) Mean tick burden on different body conditions.

Estimates

Dependent Variable: SUM

Body con.	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Poor	19.532(a)	1.339	16.900	22.165
Good	10.144(a)	1.385	7.422	12.867

a Based on modified population marginal mean.

Annex 8. Pair wise comparison in between different risk factors that were considered in longitudinal study.

a) In between different geographical zones.

Dependent Variable: SUM

(I) Geo. Zone	(J) Geo. Zone	Mean Difference (I-J)	Std. Error	Sig.(a)	95% Confidence Interval for Difference(a)	
					Lower Bound	Upper Bound
Highland	Midland	-11.731	2.153	.000	-15.964	-7.498
	Lowland	3.263	2.614	.213	-1.875	8.401
Midland	Highland	11.731	2.153	.000	7.498	15.964
	Lowland	14.994	2.575	.000	9.932	20.057
Lowland	Highland	-3.263	2.614	.213	-8.401	1.875
	Midland	-14.994	2.575	.000	-20.057	-9.932

* The mean difference is significant at the .05 level.

Univariate tests

Dependent Variable: SUM

	Sum of Squares	df	Mean Square	F	Sig.
Contrast	11771.877	2	5885.939	22.739	.000
Error	107682.170	416	258.851		

The F tests the effect of Geo. Zone. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

b) In between different seasons.

Dependent Variable: SUM

(I) SEASON	(J) SEASON	Mean Difference (I-J)	Std. Error	Sig.(a)	95% Confidence Interval for Difference(a)	
					Lower Bound	Upper Bound
Early rainy	Late rainy	11.659	2.708	.000	6.336	16.983
	Early dry	1.909	2.708	.481	-3.413	7.231
	Late dry	9.932	2.908	.001	4.216	15.648
Late rainy	Early rainy	-11.659	2.708	.000	-16.983	-6.336
	Early dry	-9.750	2.528	.000	-14.720	-4.781
	Late dry	-1.727	2.742	.529	-7.116	3.662
Early dry	Early rainy	-1.909	2.708	.481	-7.231	3.413
	Late rainy	9.750	2.528	.000	4.781	14.720
	Late dry	8.023	2.741	.004	2.635	13.411
Late dry	Early rainy	-9.932	2.908	.001	-15.648	-4.216
	Late rainy	1.727	2.742	.529	-3.662	7.116
	Early dry	-8.023	2.741	.004	-13.411	-2.635

Based on estimated marginal means
The mean difference is significant at the .05 level.

Univariate tests

Dependent Variable: SUM

	Sum of Squares	df	Mean Square	F	Sig.
Contrast	7127.502	3	2375.834	9.178	.000
Error	107682.170	416	258.851		

The F tests the effect of SEASON. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

c) In between different age groups.

Dependent Variable: SUM

(I) AGE	(J) AGE	Mean Difference (I-J)	Std. Error	Sig.(a)	95% Confidence Interval for Difference(a)	
					Lower Bound	Upper Bound
0-2 pair	3 & 4 pair	-1.371	2.318	.555	-5.926	3.185
	> 4 pair	-3.574	2.322	.125	-8.138	.991
3 & 4 pair	0-2 pair	1.371	2.318	.555	-3.185	5.926
	> 4 pair	-2.203	2.326	.344	-6.775	2.368
> 4 pair	0-2 pair	3.574	2.322	.125	-.991	8.138
	3 & 4 pair	2.203	2.326	.344	-2.368	6.775

Based on estimated marginal means
The mean difference is significant at the .05 level.

Univariate tests

Dependent Variable: SUM

	Sum of Squares	df	Mean Square	F	Sig.
Contrast	623.649	2	311.825	1.205	.301
Error	107682.170	416	258.851		

The F tests the effect of AGE. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

d) In between different body conditions.

Dependent Variable: SUM

(I) Body con.	(J) Body con.	Mean Difference (I-J)	Std. Error	Sig.(a)	95% Confidence Interval for Difference(a)	
					Lower Bound	Upper Bound
Poor	Good	9.388	1.927	.000	5.601	13.175
Good	Poor	-9.388	1.927	.000	-13.175	-5.601

Based on estimated marginal means

The mean difference is significant at the .05 level.

Univariate tests

Dependent Variable: SUM

	Sum of Squares	df	Mean Square	F	Sig.
Contrast	6146.073	1	6146.073	23.744	.000
Error	107682.170	416	258.851		

The F tests the effect of Body con.. This test is based on the linearly independent pair wise comparisons among the estimated marginal means.

9. CURRICULUM VITAE

a) Personal information

Name: Yismashewa Wogayehu

Date of birth: October 19, 1969

Place of birth: Gursum

Marital status: Married

Language skill: Amharic, Kafinono, Spanish and English

Nationality: Ethiopian

Contact address: e-mail address (yismashewa2004@yahoo.com)

b) Educational background

Period	Institution
1975-1980	Gursum elementary school.
1981-1984	Rural secondary school 4 (ESBEC 4), Cuba.
1985-1987	Rural institute of pre-university studies (IPUEC 21), Cuba.
1988-1993	Higher institute of agricultural & animal sciences of Havana (ISCA-H), Cuba.

c) Work experience

Period	Duties performed
1994-2002	I have been working as field veterinarian and animal health team leader at wereda level, SNNPRS.

d) Member of scientific society

I am member of the Ethiopian veterinary association.

10. DECLARATION SHEET

I the undersigned, declare that the thesis is my original work and has not been presented for a degree in any university.

Name________________________________

Signature______________________________

Date of submission______________________

This thesis has been submitted for examination with my approval as university advisor.

Advisor:

Dr. Abebe Wossene

Epidemiology Of Ticks& Tick-Borne Protozoal Diseases Of Cattle In Decha Wereda, Southern Ethiopia

Yismashewa Bogayehu