Institute of Agronomy and Animal Production in the Tropics
Georg-August-University Göttingen

Seasonal dynamics of ticks (*Amblyomma cohaerens* and *Boophilus decoloratus*) and development of a management plan for tick and tick born diseases control on cattle in Jimma zone, Southwestern Ethiopia

Doctoral dissertation submitted for the degree of doctor of Agricultural Science of the Faculty of Agriculture, Georg-August-University Göttingen

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Date of oral examination 18th October 2004

Dedicated

To my parents and wife Mihret Terefe

With love

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List of abbreviations used in the thesis

AAU	= Addis Ababa University
CPA	= Central Planning Authority
CSA	= Central Statistics Authority
CV	= Coefficient of variation
EASE	= Ethiopian Agricultural Sample Enumeration
ECF	= East Cost Fever
ESAP	= Ethiopia Society of Animal Production
EVA	= Ethiopian Veterinary Association
FAO	= Food and Agricultural Organization of the United Nation
GDP	= Gross Domestic Product
HSIU	= Hailesilasi First University
IAR	= Institute of Agricultural Research
Ig	= Immunoglobulin
ILCA	= International Livestock Center for Africa
ILRAD	= International Laboratory for Research on Animal Disease
ILRI	= International Livestock Research Institute
JUCA	= Jimma University College of agriculture
LD_{50}	= Lethal dose for 50 % of treated target animals
MRL	= Maximum residual limit
NGOs	= Non Governmental Organizations
NLIC	= National Livestock Improvement Conference
OAU	= Organization of Africa Unity
OIE	= Office International des Epizooties
SE	= Standard Error
TBD	= Tick Born Disease
UNDP	= United Nation Development Program

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1. Introduction

The mainstay of livelihood for 85-90 % of the people of Ethiopia is agriculture. The agricultural sector is characterized to a large extent by mixed farming system. Livestock play a vital role in the farming system of the country. In the mixed crop-livestock system of the Ethiopian highlands, livestock are mainly used for draught power, milk and meat production and source of manure (fertilizer). Ethiopia is endowed with the largest livestock population in Africa. Unfortunately, the contribution of this huge natural resource to human nutrition and export earnings is dis-proportionally low. The Ethiopian livestock contributes only 15 % to the GDP. Total herd meat off-take is estimated at around 7 % annually, which is perhaps one-third lower than the average for tropical Africa. Cattle are a prime resource for the people and government of Ethiopia. The country has the largest cattle population in Africa, estimated at 35 million head (CSA, 2002). The majorities of these cattle are indigenous *Bos indicus* breeds and are a vital component of the mixed farming system in the highlands, where they are used as draft animals for plough and for providing milk and meat. Cattle in the dry lowlands are part of the traditional nomadic life (Anon, 1977).

Government policy has recently been changed to give more encouragement to commercial farming. Local breeds are being upgraded through the introduction of purebred *Bos taurus* cattle and their crosses. There are already more than 500,000 improved cattle in the country (EASE, 2003). Although the introduction of *Bos taurus* dairy breeds may increase milk production, it may not in the absence of good management and adequate control measures against ticks and tick-born diseases (Gebreab, 1983).

Ticks infestation is severe in the western part of the country and at a conservative estimate one million US $ is lost annually only through rejection of down graded hides and skins attributed to tick damage. Babesioses, anaplasmosis, cowdriosis and theilerioses (except ECF) are the tick born diseases known to exist and to cause damage on productivity of cattle production in Ethiopia (Radley, 1980).

Studies of the ecology are the tool with which we are able to analyze the properties of tick populations and to use that knowledge in the design of more economically efficient tick and tick-born disease control and eradication programs. Firstly, ecological understanding of the nature of the problem is required. That knowledge is then used to design control strategies that are technically efficient and economically sound. Climatic favorability is the main factor that determines the geographical distribution of tick species. Years and seasons for a given tick species provide an assessment of the risk to cattle production in those areas (Walker, 1974).

Seasonal dynamics studies cover the pattern of tick abundance, the extent of fluctuations in colonizing ability of dispersing ticks and effects of interactions between tick species. Such information allows us to define the role of many variables such as climate, vegetation, cattle density and movement and cattle breed in the tick life system. Ecological studies provide efficient methods for detecting low levels of tick infestations in association with quarantine procedures. They also reveal why tick control becomes much more difficult when tick numbers on the pasture are reduced during eradication programs.

Knowledge of tick seasonal dynamics enables us to design chemical control strategies to suit different types of cattle in different environments; to calculate the losses in productivity caused by ticks and the economic benefits of control programs of different intensity; to design integrated control programs that combine different methods in a manner appropriate to a particular situation; and finally, to assess the impact of different efficiencies of novel control methods such as slow release chemicals and anti-tick pasture (Castro, 1994).

2. Literature

2.1. Ethiopian livestock production

Ethiopia's natural resources are immense and varied. Of these, livestock which plays a significant role in the countries agricultural development is renowned the biggest of African countries (table 1). This resource has, however, hitherto remained inadequately exploited and its contribution to the overall national economy has been comparatively low. Among the major reasons for the low return are the high incidences of parasitic and microbial diseases, general shortage of food and poor management of disease control.

Table 1. Number of livestock, poultry and beehives population by type and sex, for private holdings national 2001 excluding nomadic areas (CSA, 2002)

Number in thousands

Type	Sex		Total
	Male	Female	
Cattle	15675	19708	35383
Sheep	26734	8809	11483
Goats	3144	6477	9621
Horses	596	658	1254
Mules	119	137	256
Asses	1547	1868	3415
Camel	137	189	326
Poultry	-	-	37764
Beehives	-	-	3327

Table 2. Traditional division of climatic zones in Ethiopia

Climatic zone	Mean altitude (m)	Mean temperature (^oC)
Hot lowland (Kolla)	< 1800	>20
Temperate (Woynadega)	1800 – 2400	16 - 20
Cool alpine (Dega)	> 2400	< 16

2.2. Tick

Ticks are obligate ectoparasites and are well known as important vectors transmitting pathogens to animals and humans in many parts of the world. There are at least 840 tick species in two major families, namely the *Ixodidae* comprises approximately 80 % and *Argasidae* 20 %. There are two well-defined families of ticks, the Ixodidae or hard ticks and the Argasidae or soft ticks, and the two groups differ from each other markedly in appearance, habits and development (Pegram *et al*., 1987).

2.2.1. Tick biology

2.2.1.1. External structure of *Ixodidae*

The Family of *Ixodidae* is varied in shape and species. As the scientific nomenclature indicates (ixos gr. = fly glue, ixodes= glued), they are sticking ticks and stationary parasites. Ticks belong to the super order of *Acarina,* which have certain characteristics that distinguish them from other arachnids such as spiders. It has a rounded body, without a clear boundary between the anterior and posterior parts. The body is divided in to a capitulum (gnathosoma) and the rest of the body (idiosoma). It has six pairs of appendages including the chelicerae, pedipalps, and four pairs of locomotors appendages (Aeschlimann and Morel, 1967; Morel, 1989).

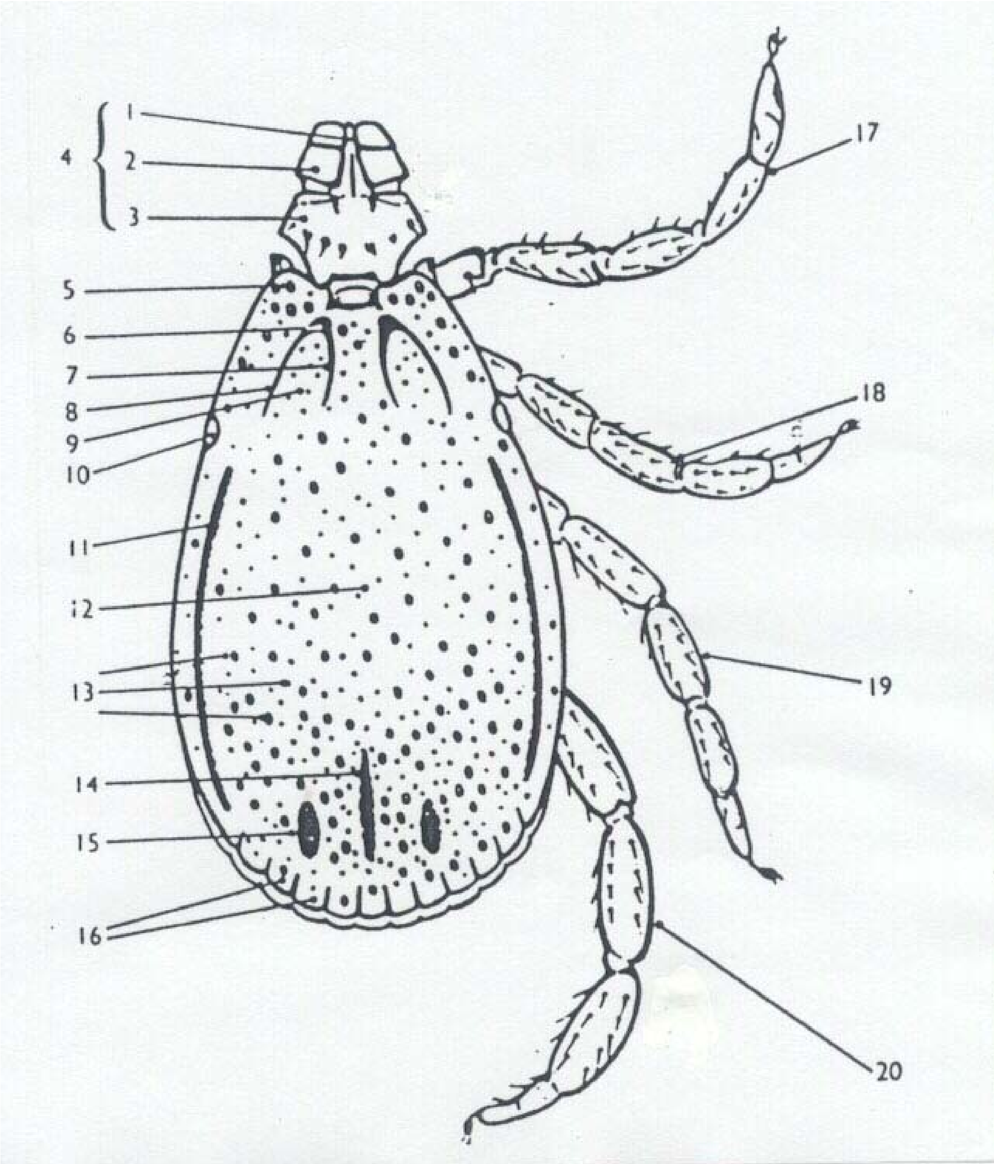

Figure 1. External structures of dorsal surface of male tick (Lewis, 1939)

1. Hypostome
2. Palp
3. Basis capituli
4. Capitulum
5. Scapula
6. Cervical pit
7. Cervical groove
8. Lateral groove
9. Cervical field
10. Eye
11. Marginal groove
12. Conscutum
13. Punctuations
14. Posterio-median groove
15. Posterio-lateral groove
16. Festoons
17. Leg I
18. Leg II
19. Leg III
20. Leg IV

2.2.1.2. Internal structure and physiology of Ixodidea

The digestive tract includes a sucking pharynx with powerful muscles, an esophagus and a central located stomach with several anterior and posterior ceaca on both dorsal and ventral sides. All the diverticula's are filled during the blood meal and occupy the empty spaces of the haemocoel. Muscles and other organs that pass between them separate the ceaca. The stomach is linked to the excretory ampulla by short intestine.

The excretory system is made up of two Malphigian tubes that join in an excretory ampulla connected to the anus. They cling with their host with oral apparatus and engorge themselves once during each stage of development. Feeding in ticks is a sequence of nine events:

- Appetence:- the seed tick move to the top of the grass blade and kept in form of clusters wait for passing host,
- Engagement:- the tick climb onto suitable host,
- Exploration:- the tick move on the host and explore for their predilection site**,**
- Penetration:- penetration by tick is not only mechanical, but also involves physicochemical phenomena. Once they found their favorite site the chelicerae tear the epidermis superficially by movement of the hooks until it reach the dermis. Tissue digestion around the penetration channel causes capillary and lymphatic ruptures,
- Attachment: - salivary secretion immediately soften and digests the lesion site the hypostome then penetrates slowly under combined action of the chelicerae and the saliva. The salivary secretion made up of lipoproteins and glycoprotein’s that covers the hypostome solidifies slowly to tighten the temporary attachment**,**
- Ingestion:- the tips of the hypostome and its chelicerae are free for ingestion. The ticks feed by suction from a hemorrhagic cavity, alternating with injection of saliva,
- Engorgement:- during the meal, the hypostome and envaginated sheaths of the chelicerae fill the lumen of the attachment channel. Engorgement is slow at first, and then accelerates. The female doubles in volume by the end of the blood meal,

- Detachment:- upon withdrawal, the chelicerae sheaths envaginated leaving a free space within which the hypostome can move back ward, and
- Disengagement:- the sheath remains in place after the tick has dropped off (Allen, 1994).

Moreover, to fully elucidate the mechanism that controls the host-tick interaction process on a seasonal basis, we need to understand the influence of environmental factors on appearance engagement, and exploration (Douglas, 1996).

The hypostome of the attached *Ixodidea* is not in direct contact with the damaged tissues, but surrounded by a hyaline sheath of a concentric laminar structure. Only the tips of the hypostome inserted in the tissue and its chelicerae are free. A special intermittent salivary secretion produces this sheath. It covers the hypostome around which it solidifies slowly. The length of the hyaline sheath corresponds to that of the hypostome and sometimes could be deeper (Uilenberg, 1990) (Figure 2).

The respiratory organs are the tracheae that open through the stigmated spiracle behind the fourth pair of coxae lungs are absent. The pulsatile dorsal heart that is elongated in the form a vessel ensures the circulation. The sex genitalia are initially paired and then combine in a single mass in the posterior part of the body. The eliminatory ducts originate from this mass and unite in front into a single duct that opens through the genital pore. The nervous system consists of a cephalic ganglion (Aeschlimann and Morel, 1967).

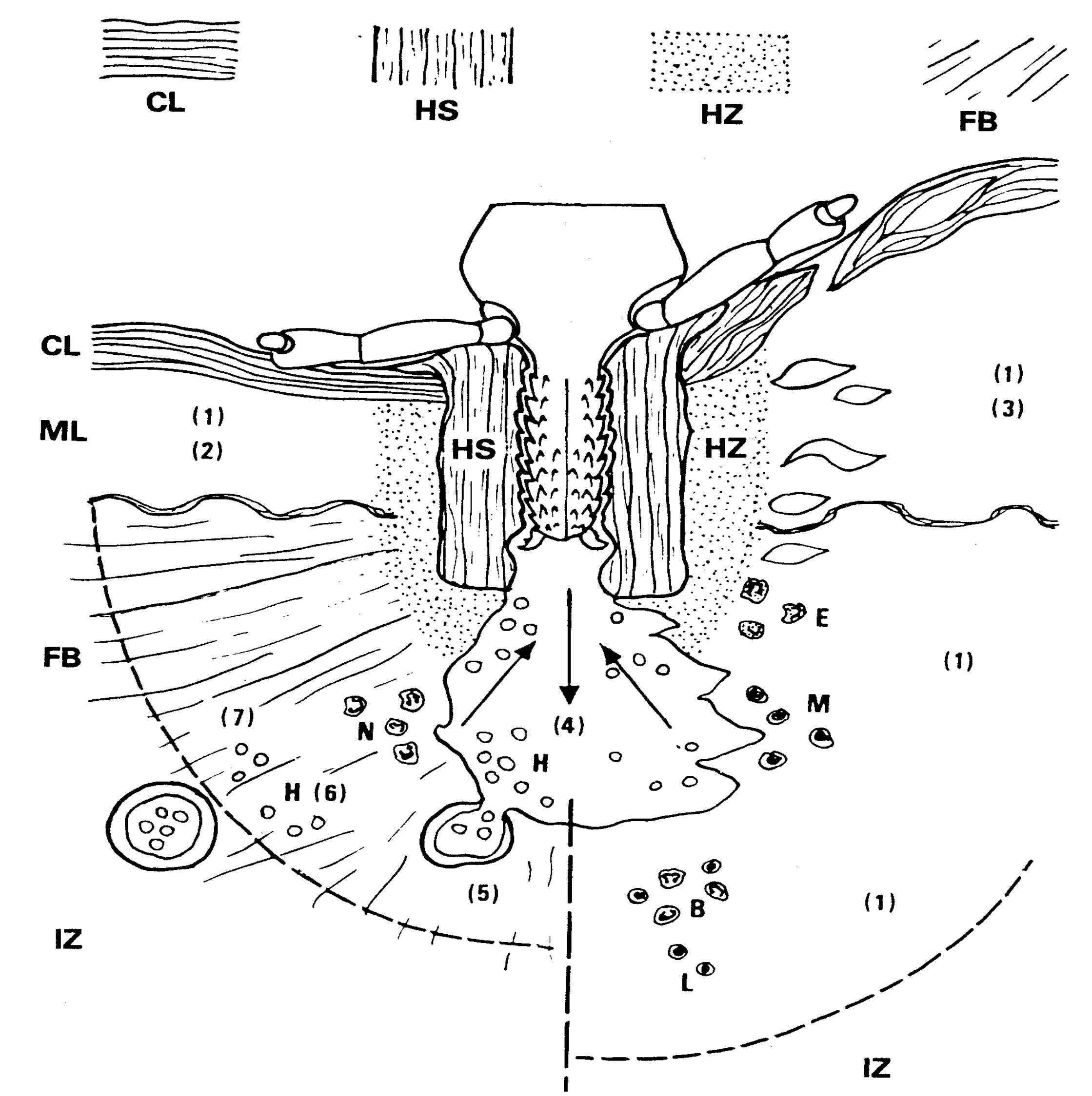

Figure 2. Attachment lesion of a tick (Chartier et al., 1989)

1. edema	B. Basophils (histamines)	CL. corneous layer
2. hyperplasia	E. Eosinophils	ML. Malpighian layer
3. acantholysis	H. Haemocytes	FB. Fibroblasts
4. cytolysis area	L. Lymphocytes (antibodies)	HS. Hyaline sheath
5. vascular rupture	M. Mastocytes	HZ. Homogenous zone
6. extravasations of blood	N. Neutrophils (lysosomes)	IZ. Intact zone
7. fibrous zone		

2.2.2. Development of ticks and influencing factors

The preservation of the species is only guaranteed because *Ixodidae* produce enormous numbers of eggs. Under suitable climatic conditions mostly hot and humid, the eggs open after a while and six-legged larvae emerges. They wait on the tops of plants for a host animal to pass by. They localize their target by means of their chemoreceptor (Haller organ) which is on the upper side of the tarsus and, by waving its fore legs in the air, they manage to cling on to the host animal. They are especially attracted by dark, moving objects; a long hair coat makes it easier for the *Ixodidae* tick to attach itself to the host (Seifert, 1996).

As soon as they found host, the larva seeks out places on the animal where they are protected and have favorable conditions for their development. They prefer to bite into thin part of the skin. At this point, the saliva is used not only to inhibit blood coagulation, but also as local anesthetic. In a course of about six days they feed without interruption on blood after which they molt.

This is the stage when the eight-legged nymphs, that are sexless, emerge. As soon as the nymphs hatch out on the ground or on the host depending on the species, the act of feeding is repeated and after molting again, the eight legged imagines that are sexually differentiated emerge. It is usually only the female imagines which feed on blood and only half of their body, which is covered with the shield, expands to the size of a bean or even a pigeon's egg. During their feeding, they copulate with the males that scarcely feed on blood and spend their time creeping around on the skin of the host (Seifert, 1996) (Figure 3).

2.2.2.1. Life cycle of Ixodidae

In *Ixodidae,* three types of life cycles can be distinguished based on similarities or differences in tropisms shown by ticks at different instars. These are the monotropic cycle or one-host, the ditropic cycle or two-host and the telotropic cycle or three-host ticks. According to the species, the development is either completed on one, two or three hosts.

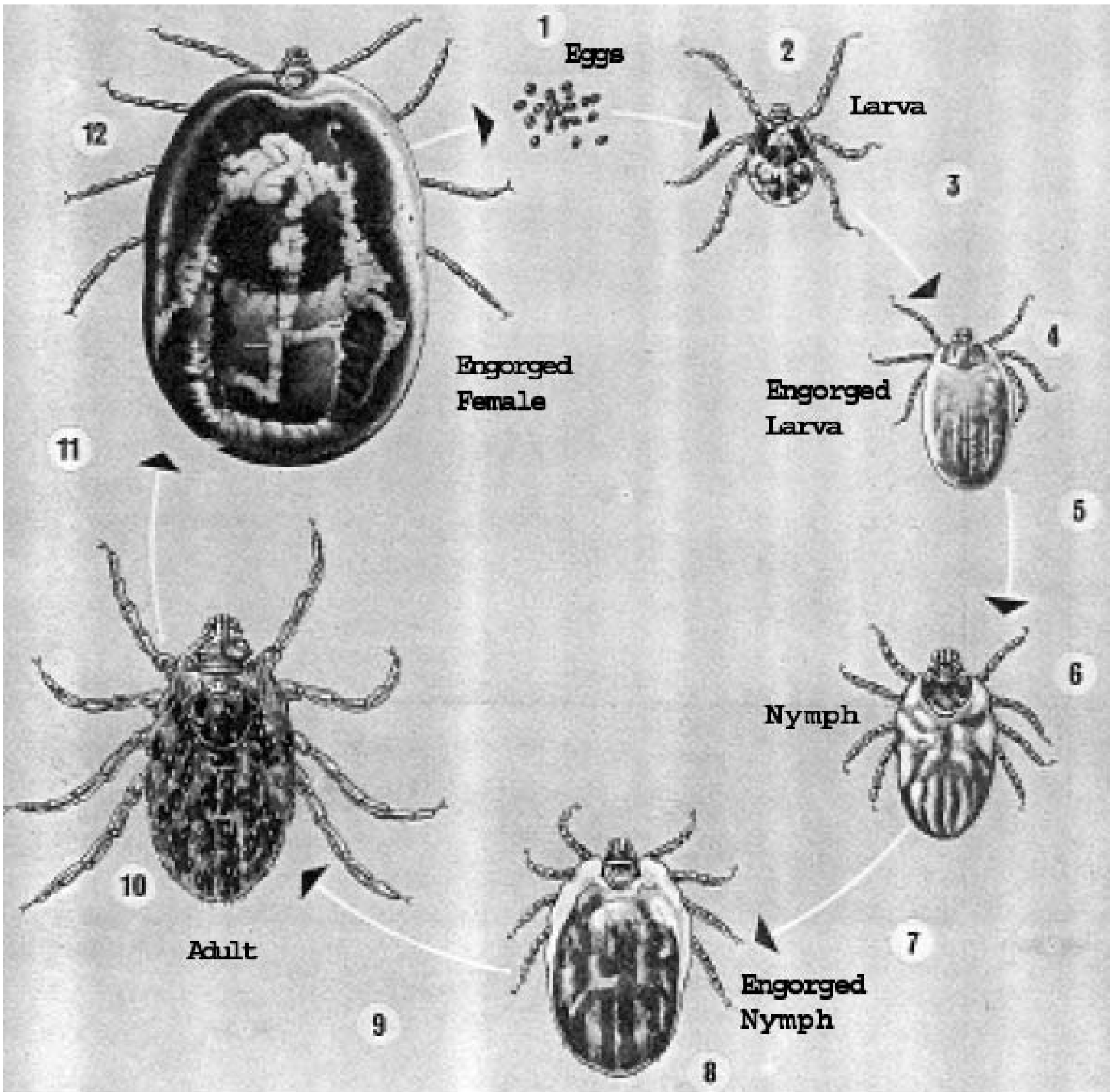

Figure 3. Life cycle of ticks (Brian, 1997)

In **one-host ticks**, the larvae that emerge from the eggs three to four weeks after deposition at the earliest attach themselves to a host animal where they complete their entire development. On the host they develop to nymph then to adult and then copulate. Afterwards, they drop off and deposit their eggs on the ground. The entire development cycle takes mostly 19-21 days as a rule, with minimum of fifteen and maximum of 40 days, each stage taking one week (Seifert, 1996). In these ticks a stricter adaptation eliminates the need to drop to the ground for metamorphosis. All the instars occur on a single vertebrate, attacked by the larva. The larval and nymphal metamorphoses take place on the host, at the point of attachment of the larva and nymph. There is only one parasitic phase (Douglas, 1969) (Figure 4).

The **two-host ticks** attaches itself as a larva to a host, feeds on blood and develops into the nymph stage. After a maximum of 14 days, it drops off on to the ground where it reaches the imago stage in 20-30 days time. Male as well as female ticks then look for another host, feed on blood and copulate. After 6-11 additional days, the female drops to the ground and deposits its eggs. The entire cycle from the time the larva emerges until the engorged female deposits the eggs mainly depends on the time the adult spent on the ground to find a new host. According to the species the nymph may survive on the ground for several weeks (Seifert, 1996). In these ticks the three stages develop on two different individuals that may or may not belong to the same species. In the first phase, the engorged larva molts on the host and the nymph reattaches close by. At the end of the blood meal, the nymph detaches and metamorphoses on the ground. Engorgement of adults occurs during the second parasitic phase. There are only two searches for a host, which eliminates the risks linked with the need for nymphal attachment (Hopla *et al.,* 1994) (Figure 5).

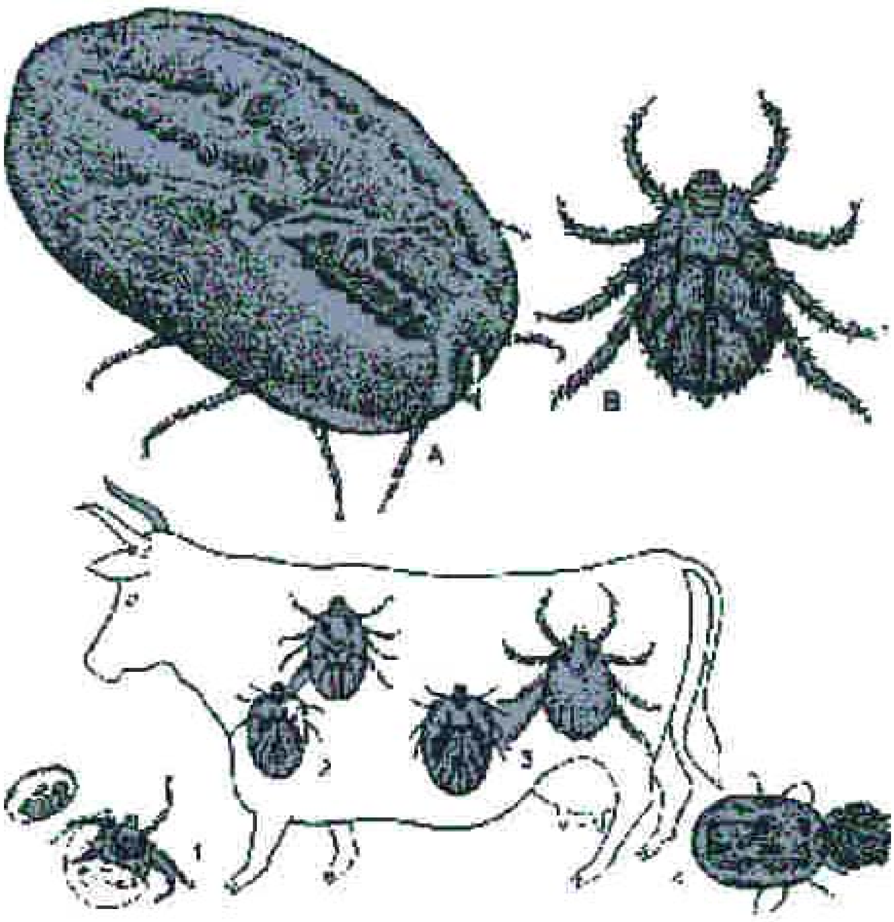

Figure 4. Development of one host tick (A: engorged female tick; B: male tick) (Seifert, 1996)

1: Larvae hatched from the egg. 7-10 days later the larvae climb onto vegetation and search for a host. 2: The larvae find a host and feed on blood for 3-5 days. They molt afterwards, and the hatched nymphs feed on blood for 3-6 days. 3: The fully engorged nymphae enter a stage of molting which lasts 2 days, and from which develop sexually differentiated males and females. During mating, the female feeds on blood for 4-5 days and finishes its residence on the host with a large blood meal. 4: About 30 days after the larva has found a host, the fully engorged females drop to the soil and deposit the eggs.

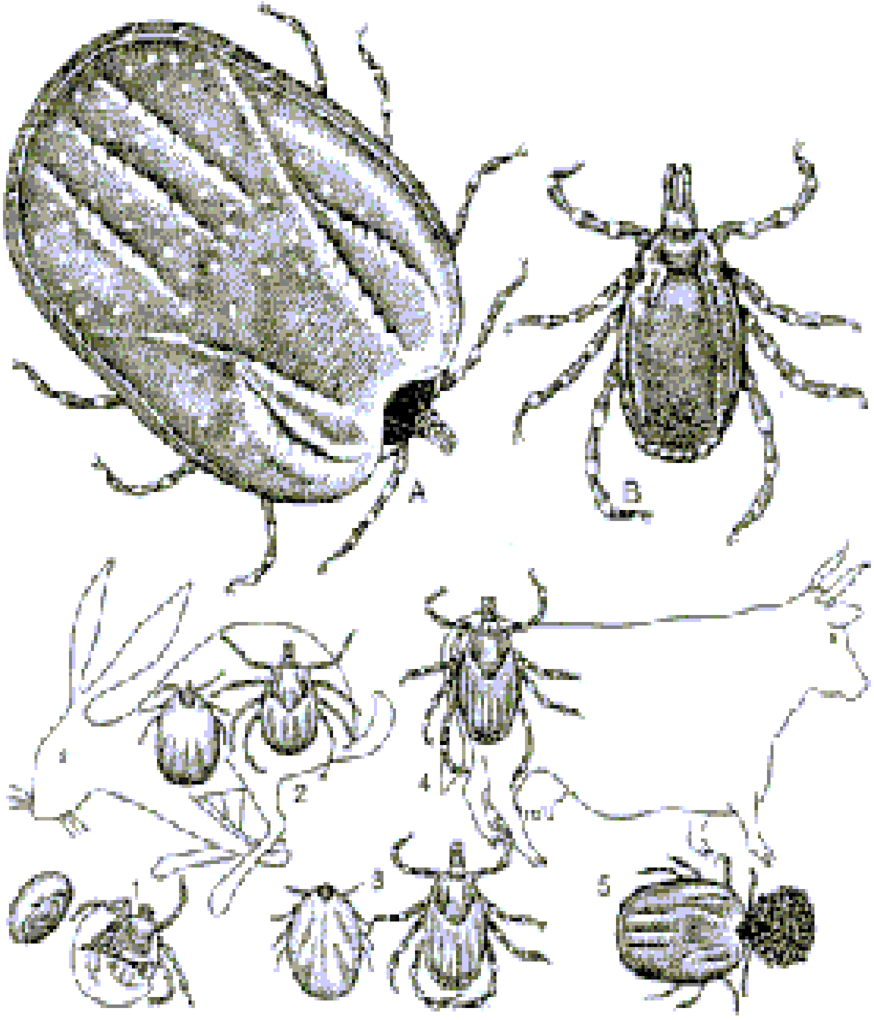

Figure 5. Development of two host ticks (A: engorged female tick; B: male tick) (Seifert, 1996)

1: The hatched larvae search for a host from small mammals or birds. 2: The larvae feed on blood and hatch to nymphae. Subsequently the nymphae take their blood meal. 3: The fully engorged nymphs drop to the soil, the sexually differentiated males and females hatch and find a new host; they regularly choose large animals. 4: The adult attaches to the host copulate and females take large blood meal. 5: The fully engorged females drop to the soil and deposit the eggs.

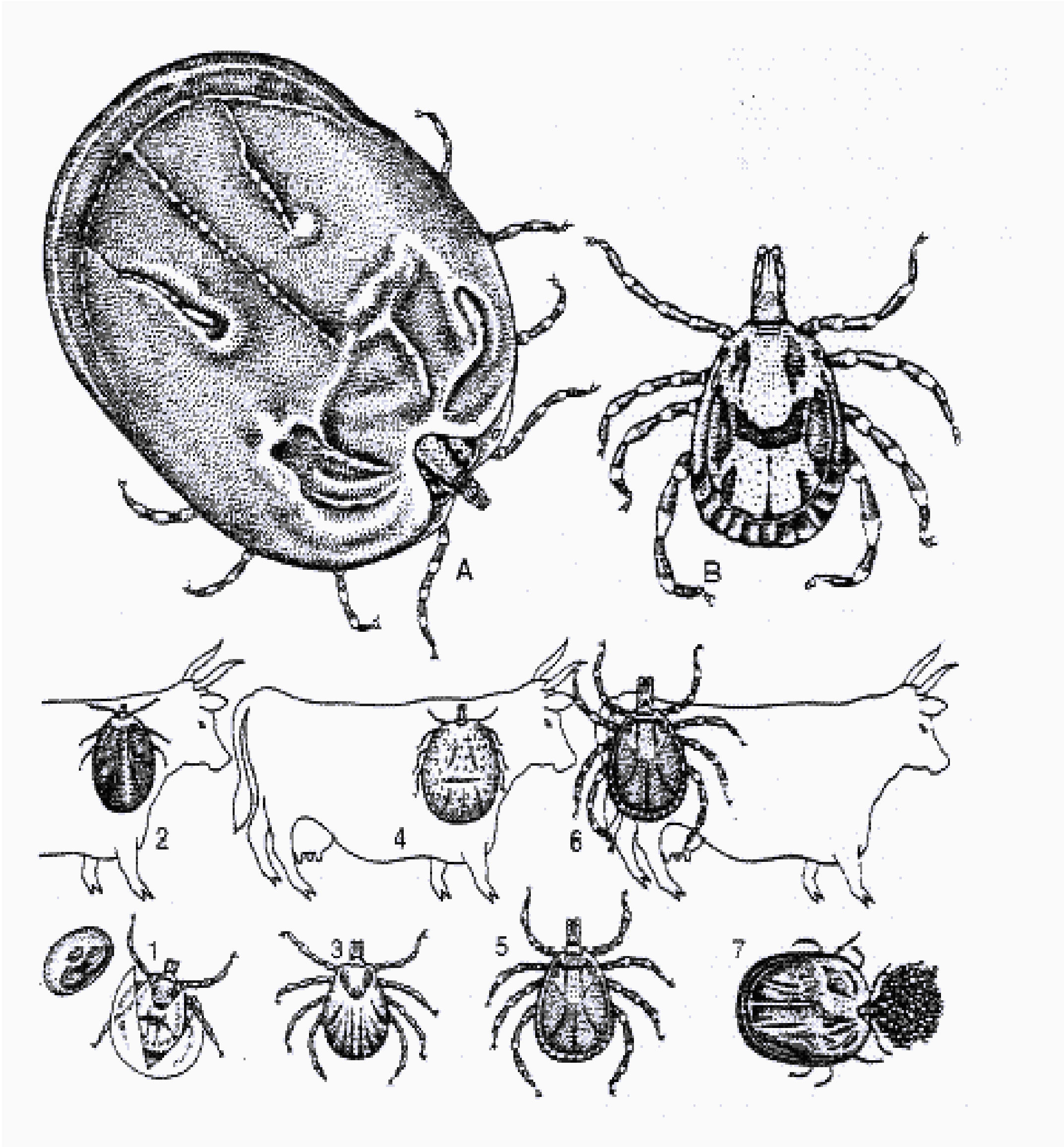

Figure 6. Development of three host ticks (A: engorged female tick; B: male tick) (Seifert, 1996)

1: The hatched larvae climb on vegetation and search for a host. 2: On the host the larvae feed on blood. 3: The fully engorged larvae drop to ground and hatch to nymphae. 4: The nymphae search for a host and feed on blood. 5: The fully engorged nymphs drop to the ground, and sexually differentiated males and females hatched. 6: The adult attaches to the host copulate and females feed on blood. 7: About 10 days after finding its host, the fully engorged females drop to the soil and deposit the eggs.

The **three-host ticks** looks for a new host during each stage of development in order to feed. The larva emerges from the egg on the ground, looks for a host, feeds on it for three to seven days, drops off and molts after three to four weeks on the ground. The nymph attacks a second host for three to seven days feed on it and drops and develops into an adult on the ground after two to eight weeks. After that, the adult tick looks for a third host to feed on and for copulation that takes one to three weeks. Finally it drops off and completes the cycle with oviposition on the soil. Because of the different time spent in each stage on the ground, the entire development cycle may last up to one year (Seifert, 1996). These 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 (Hopla *et al.,* 1994) (Figure 6).

2.2.2.1.1. Egg

The engorged female detaches from its host and oviposits in natural shelter, either under a stone or in plant litter, broken walls, soil crevices, burrows, etc. Oviposition occurs after a period of digestion and oogenesis. The number of eggs depends on the size of the blood meal and the size of the female of a given species (1000-20000 eggs). During this process, the female lays the eggs in a mass in front of her and withdraws, leaving a trail of eggs. The emptied female then dies after a single oviposition. The incubation period varies with the species and ambient temperature. Lack of humidity or a sudden change of temperature may destroy the eggs. Embryogenesis usually lasts 20-50 days (Walker and Fetcher, 1982).

2.2.2.1.2. Larva

The newly hatched larva is six legged, swollen and soft. It takes several days to harden, lose a certain quantity of water, and eliminate metabolic waste products accumulated during embryogenesis. After this time, it begins to seek the first host, either lying on a grass blade and wait for it, or moving actively to hunt the host. At other time it shelters in a resting place, its activity depending on the ambient temperature and humidity.

They are particularly active in the early morning. Light of moderate intensity stimulates their upward movement. In the absence of hosts larvae are able to survive for three to four months in dry and hot climate and five to six months in humid and hot areas. Once the host is found, the blood meal lasts for three to twelve days or more, depending on the species and ambient conditions, the larva increases considerably in size. Its volume will determine the size of the nymph. There is complete metamorphosis requiring total immobility and an overall reorganization of the tick, so the next instars has a different form. The duration of the metamorphosis is two to eight weeks, depending on the microclimatic conditions; it ends with the emergence of a nymph (Teel *et al.,* 1988).

2.2.2.1.3. Nymph

The eight-legged nymph after period of hardening, its activity is similar to the preceding larval instars in terms of movement and selected host. The feeding period is also approximately the same. Subsequently the nymph undergoes 2^{nd} complete metamorphosis and ends with the emergence of sexually differentiated adult (Teel *et al.,* 1988).

2.2.2.1.4. Adult

The size of adults may vary considerably depending on how favorable the conditions are for the nymph and larva. After a period of rest and maturation, the adults seek a third host. The duration of the blood meal is longer than for the pre-adult stages and also depends on the surrounding temperature. Mating sometimes occurs on the ground. More often it occurs on the host at the time of the blood meal. A virgin female cannot complete engorgement (Walker, 1962).

2.2.2.2. Duration of the life cycle

The length of this period is determined by the possibility of survival in the free-living state. Such periods occur three times for three-host ticks, and once for one-host ticks. The life cycle may be prolonged for several reasons. Host finding may be extended by several weeks or months. Diapauses due to seasonal rigors winter cold in Europe, heat and drought from March to June in Sudanese savannas prolong the entire cycle for a season or more. Delays due to slow blood meals are negligible compared with the preceding factors. A slow natural rate of development, particularly the stages of organogenesis (egg development, metamorphosis) also extend the life cycle. One and two host ticks develop faster than three-host ticks since they metamorphose on the host. Based on these factors, several development patterns can be identified (Kaiser, 1987).

2.2.2.3.1. Diapause's syndrome in life cycle

Diapause's syndrome is defined as a neurohormonal mediated dynamic state of low metabolic activity. Associated with this is reduced morphogenesis, increased resistance to environmental extremes and altered or reduced behavioral activity. Diapause's occurs during a genetically determined stage of metamorphosis and its full expression develops in a species-specific manner, usually in response to a number of environmental stimuli that precede unfavorable conditions. Once diapause's has begun, metabolic activity is suppressed even if conditions favorable to development prevail (Berkvens *et al.,* 1994). Some scientific reports on the subject had pointed out that diapause's must be of prime adaptive significance in adjusting the tick's entire life cycle to seasonal change and should not be regarded merely as a means of avoiding adverse climatic conditions or seasonal food shortages (Belozerov, 1982).

2.2.2.3.1.1. Types of diapause's

There are two types of diapauses

- Behavioral diapause's is characterized by the suppression of host seeking activity by unfed ticks.
- Morphogenetic diapause's results from the blocking of some essential steps in development, such as embryogenesis or metamorphosis of larvae and nymphae (Belozerov, 1982).

2.2.2.3.2. Variation in diapause's syndrome

Diapause's induction: After the sensitive stage perceives the diapause's inducing stimuli changes occurs in the tick (token stimuli). Pre-diapause's and early diapause's changes ensure that the proper stage for diapause's indication at the correct time of the year.

Diapause's development: The progress towards the completion of diapause's in a timely manner.

Diapause's duration: Species specific and or strain specific characteristics, ranging from several weeks to several years.

Diapause's maintenance: In nature, one or more mechanisms can maintain diapauses. Sensitivity to day length and altered thermal threshold for diapause's developments are most common. Therefore, to be ecologically meaningful, investigations of diapause's development should consider numerous interacting and constantly changing variables, such as the altering reactions of organisms and seasonally changing environmental factors (Berkvens *et al.,* 1994). Prolonged diapause's is a bet-hedging tactic in response to adverse environmental conditions. The ultimate duration of diapause's depends on the interaction between the genetic characteristics of species, strain or individual, the environmental factors that determine diapause's depth, the sensitivity of stages perceiving the stimuli, the environmental conditions that determine the rate of diapause's development (i.e. the physical conditions during the diapause's and need for, and seasonal occurrence of a diapause's terminating stimulus) (Punyua *et al.,* 1991).

Diapause's termination: The termination of diapauses is dependent upon stimuli received from outside the tick. Long day length often can terminate both laboratory induced and natural diapauses. Diapause's can either end gradually, without the intervention of a specific stimulus, or require the occurrence of a diapause's terminating stimulus. Diapause's terminating stimuli may act in very subtle ways and revealing them requires experiments with precisely controlled conditions.

Post diapause's quiescence: Development in the post diapause's transitional period is directly dependent on prevailing environmental conditions. Token stimuli no longer prevent growth and development when thermal (development thresholds) and other responses have returned to non-diapause's level. If conditions after diapauses are not favorable for growth and development, the diapause's syndrome may persist for varying periods. This post diapause's transitional period may include a period of post diapause's quiescence, during which the diapause's syndrome is retained until the arrival of favorable conditions (Belozerov, 1982).

2.2.2.3.3. The importance of behavioral diapause's

There is some controversy over factors that control diapauses and whether ticks in southern and central Africa would survive in eastern Africa and vice versa. The important feature was that the population dynamics of different ticks are quite different in the southern part of its distribution from those in its northern part and this was controlled by the absence or presence of adult diapause's (Pegram *et al.,* 1982; Gebre, 1994).

Interpretation of results obtained in field exposure of ticks to quasi-natural conditions is difficult. If ticks were left on the field in June and were not treated, the ticks would become active at the natural time in December the same year. However, if they were kept at a lower temperature and higher humidity (due to shade and watering) than normal, the ticks would terminate diapauses at an unnatural time in April/May the next year. Adult ticks produced from nymphae fed in March would feed quite naturally in April. It is important to be able to define factors controlling diapauses in order to be able to model the population dynamic accurately (Yehualashet *et al.,* 1995).

2.2.2.4. Life cycle influencing factors

2.2.2.4.1. Host factors

a. Character of the hosts

The adults of many ticks occur on the grass cover and have access to a wide range of host's ungulates or carnivores, wild or domestic. They are not specific but selective towards a group of vertebrates based on their size and origin and mobility. The indigenous wild animals of a given region are important factors regarding the origin and maintenance of population of domestic mammal ticks. The different instars of a given species may or may not have definite microclimatic requirements. These determine their location in the most suitable microhabitat and the choice of hosts according to availability at different levels of the plant cover (Morel, 1980).

Specific ticks are associated with hosts of a definite resting site or habitat. The area is small or with a distinct environment nest, burrows, caves, rock piles, thickets, dense reverie forests, wet lowlands. This phenomenon is due to the tick's ecological specialization in relation to that of the host, rather than phylogenetic specificity of the tick (Samir, 1980; Morel, 1989).

b. Predilection sites on the hosts

On initial infestation, ticks were picked up during the day when cattle were grazing, and attached temporarily near the hooves. Subsequently, when cattle rested, especially at night, the ticks detached and then reattached more firmly at the usual predilection sites. Many ticks disappeared during relocation, and other ticks transferred to different hosts. The tick's location on the host is linked to the possibility of penetration by the hypostome. On ungulates, species with a short hypostome usually attach to the head within the ear, nape of the neck, margin of the anus, and under the tail. Long-hypostome species attach to the lower part of the body where the skin is thicker, such as the dewlap, groin, udder, testes, perineum, and margin of the anus. Small ticks, all instars of *Boophilus*, larvae and nymphs of *Amblyomma* have no marked preference, and can be found all over the body (Strachurski, 2000).

2.2.2.4.2. Climatic factors

Ticks are found on all continents and are bound to certain climates as far as the requirements for temperature, humidity, sun-radiation and shade of each species are concerned. Furthermore, each species requires specific environmental conditions for its habitat. The respective species only have a chance for survival when these prerequisites are fulfilled (Seifert, 1996). Ticks in a tropical zone the more rapid development pattern are determined during the beginning rainy season. The whole cycle takes one year. Whereas, ticks in an equatorial zone climatic uniformity and the absence of an unfavorable season allow development throughout the year. There is no annual cycle determined by a diapause's, generation follow one another in a pattern depending on the species (Walker and Fletcher, 1982).

a) Temperature: a dynamic factor

Each species has its particular threshold temperature below that diapauses occurs in all instars. Egg and larvae development, and egg production in engorged females are inhibited, while immature and unfed adults become quiescent. The average weekly or monthly temperature is useful for predicting the activity threshold and optimum temperature. The tick development and activity periods can be determined from monthly isotherm charts.

b) Relative humidity: a static factor

Relative humidity is considered at microclimate level. Humid rather than wet conditions are essential for the development and survival of eggs, and the survival of unfed hatched larvae. Each species is adapted to a particular relative humidity range in a biotope and it varies with the instars and its size. Larvae and nymphs have high humidity requirements, whereas the adults can protect themselves better against evaporation because of their larger size and thicker tegument. The requirement ranges from 100 % to very low relative humidity.

Larvae and nymphs adept their humidity requirements by developing in holes in the ground, cracks in rocks, litter, and the base of the vegetation layer and other shelters places. They may alternatively immediately seek a host and not leave it before the engorged female stage. The surface of medium-height (30-150 cm) vegetation and especially bare ground (sand, pebbles, rocks) are less protected. Ticks rarely occur in these sites except under special circumstances in all seasons if adults have thick teguments, or only in the rainy season, or if the site is shaded by a tree to prevent evaporation. Larvae or nymphs found in open spaces are usually active in the rainy or cool seasons (Morel, 1989).

c) Climate related factors: seasonal activity

Climatology includes the particular temperature and humidity conditions prevailing in a country. These parameters are the result of the simultaneous action of several factors, such as latitude, altitude, and their effects sunlight, temperature, rainfall, wind patterns. On a regional scale, these data should be studied for a better understanding of vectors and the diseases they transmit, especially for the application of control measures (Pegram *et al.,* 1982).

In a region with uniform conditions, a comparison of data on species distribution with isotherm and isohyets maps enables the identification of natural distribution zones in relation to latitude. In mountainous regions, the determining factor is altitude. Various climatic factors condition the presence or absence of a tick species. According to its micro or mesoclimatic requirements, the species will be found in certain similar bioclimatic zones, and not in others. Moreover, seasonal variations within a bioclimatic zone will favor or hinder the development or activity of a tick species during certain periods. In tropical climates, the dominant factor is rainfall. The start and end of the rainy season influence the different phases of the life cycle. Parasitism is reduced during the dry months and increases sharply within days following the first major winter rainfall. The population remains stable for a few weeks, and then slowly diminishes.

At the end of the rainy season, there is a marked decrease, with progressive fall to almost zero in the dry season. Tick distribution therefore corresponds to the isohyets. In these cases, the cold and dry seasons impose pattern on tick development that can be observed in parasitism in large mammals. The cycle of seasons determines the alternation of appearance, reduction, and disappearance of ticks. These variations in tick populations represent the frequency or seasonal dynamics of a species, or its phenology (seasonal pattern of appearance) (Fourie *et al.,* 1996).

2.2.2.4.3. Vegetation

The plant cover as a whole is not an inert intermediate factor between climatic phenomena and the fauna, since it is not in depressant of these factors. It is the result of the adaptation of a particular flora to the temperature, rainfall, and wind patterns prevailing in an area with particular geological and pedological characteristics. In turn, vegetation is also related to temperature and rainfall. Its distribution and feature in given latitude and altitude represent equilibrium. It is a response to external conditions that creates variety of microclimates at different levels and physical support to the fauna (Glen and Pete, 1969).
Vegetation is not only the result of various elements that make up the environment, but it also determines, by its composition, the various microclimates at different levels. It is the best ecological integrator, which influences the biological phenomena seen at a given point. A comparison of the distribution of tick species with the features of the vegetation in a natural zone is very useful. It is of practical use for determining the distribution of a given species, with all the consequences concerning the epidemiology of diseases caused or transmitted by ticks and the possibilities of controlling them (Morel, 1989).

2.2.2.5. Definitions of related terms on seasonal adaptations

Phenology is a set of adaptations that leads to the seasonal timing of recurring biological events such as growth, development, reproduction, dormancy or migration.

Dormancy is a general term that refers to a seasonally recurring period (phenophase) in the life cycle in which growth, development and reproduction are suppressed. At a physiological level, this involves diapauses or quiescence or both (Fourie *et al.,* 1996).

Photoperiod: - the dynamic action of photoperiod on the full expression of the diapause's syndrome makes it apparent that diapause's has evolved to take advantage of the seasonal progression of photoperiods. The critical photoperiod is that which elicits 50% response, either inducing or terminating diapause's (Singh and Singh, 1999). For photoperiod response it is not important whether day lengths are increasing, decreasing or stationary the only significant factor for species is the duration of day in relation to the critical photoperiod. It responds to change in day length without reference to a critical photoperiod (Belozerov, 1982)

The frequency of most ticks varies in the different natural zones. In tropical Africa, principal activity of adults during the rainy season peaks at the beginning and in the middle. The generations follow one another, and overlap. The seasonal dynamics of a species determine tick host relations in the epidemiology of a transmitted disease. They should be taken into account in treatment schedules (Berkvens *et al.,* 1994).

2.2.3. Ticks distribution of Ethiopia

2.2.3.1. General

The main tick genera found in Ethiopia are *Amblyomma, Boophilus, Haemaphysalis, Hyalomma* and *Rhipicephalus*. The most important and widespread tick species are *A. variegatum* (vector of *Cowdria ruminantum* and *Theileria mutans*) and *B. decoloratus* (vector of *Anaplasma marginale* and *Babesia bigemina*). There is no report of the presence of *R. appendiculatus* (vector to *T. parva*). The effects of ticks on indigenous cattle compared to exotic breeds shown to be minimal. However, over 50 species are known to exist in the country (Morel, 1980; Mekonnen *et al.,* 2001).

The major tick genera recorded during tick distribution survey 1989-1991 in southwestern Ethiopia were *Amblyomma* (40 %*), Rhipicephalus* (37 %), *Boophilus* (21 %)*, Hyalomma* (1.5 %) and *Haemaphysalis* (0.5 %). *Amblyomma, Rhipicephalus* and *Boophilus ticks* are mainly parasites of livestock. The remaining species occur in limited numbers and have little practical significance to livestock production in the region. *A. cohaerens* and *B. decoloratus* predominates in southwestern Ethiopia, these two species constitute more than 40% of the total collections. Tick population levels in local cattle are generally low most of the time of the year and the number increases during rainy season (Castro, 1994; Mekonnen *et al.,* 2001).

Table 3. Economically important tick species in Ethiopia (Mekonnen, 1996)

Tick species	Host
Amblyomma cohaerens	Cattle, sheep, goat, camel, equine
Amblyomma gemma	Cattle, sheep, goat, camel
Amblyomma variegatum	Cattle, sheep, goat, camel
Amblyomma lepidium	Cattle, sheep, goat, camel
Boophilus decoloratus	Cattle, sheep, goat, camel, equine
Rhipicephalus bergeoni	Cattle, sheep, goat, equine
Rhipcephalus evertsi evertsi	Cattle, sheep, goat, equine
Rhipcephalus pulchellus	Cattle, camel, equine
Hyalomma truncatumi	Cattle, sheep, goat,
Hyalomma marginatum rufipes	Cattle, sheep, goat, camel
Hyalomma dromedarii	Cattle, sheep, goat, camel

List of the ticks in Ethiopia (Pegram, 1981; Gebreab, 1983).

1. *Amblyomma cohaerens*
2. *" variegatum*
3. *" lepidum*
4. *" gemma*
5. *" marnoreum*
6. *" eburneum*
7. *" nuttali*
8. *" rhinocerotis*
9. *" habraeum*
10. *Rhipcephalus pulchellus*
11. *" evertsi evertsi*
12. *" longicoxatus*
13. *" longismus*
14. *" mushame*
15. *" paravus*
16. *" saguineus group*
17. *" senegalensis*
18. *" simus*
19. *" armatus*
20. *" bursa*
21. *" camicasi*
22. *" supertritus*
23. *" sulcatus*
24. *" bergeoni*
25. *Rhipcephalus lunacutus (tricuspis)*
26. *Hyalomma anatolicum*
27. *" excavatum*
28. *" dromedarii*
29. *" erythraeum*
30. *" impelatum*
31. *" marginatum marginatum*
32. *" marginatum rufipes*
33. *" turanicum*
34. *" punt*
35. *" truncatum*
36. *Haemaphysalis aciculifer*
37. *" parmata*
38. *" bequaerit*
39. *" leachi mushami*
40. *" leachi leachi*
41. *" spinulosa*
42. *Boophilus decoloratus*
43. *" annulatus*
44. *Aponoma exornatum*
45. *Argas persicus*
46. *Ornithodoros moubata*
47. *" savignyi*

2.2.3.2. Relevant tick species in southwestern Ethiopia

2.2.3.2.1. Boophilus decoloratus (Koch, 1844; Hoogstraal, 1956)

General: - B. decoloratus is a one-host tick. The larvae can survive for eight months without food, on finding a suitable host show predilection for the dewlap and neck, or else at the tip and outer edge of the pinnae of the ears. Having fed to engorgement the larvae remain for a week before molting to nymphs and finally to adults, the adults move to the flanks and the belly for feeding, and females detach themselves 23 days after having attached as larvae. Males generally remain on the host for further 4 weeks. After a preoviposition period of about 6 week, some 2000 eggs are laid, and under laboratory conditions they hatch in about 5 weeks. All stages of B. decoloratus occurre on cattle throughout the year, reaching peak infestations in rainy season.

On this species the limiting factor affecting its geographical distribution is the degree of aridity that is represented by an annual precipitation of 15 in. Temperature does not appear to be a restrictive factor, and the species is tolerant of a wide range of such conditions as indicated by its wide horizontal distribution and its vertical distribution from sea level to about 8000 ft. in Kenya (Hoogstraal, 1956).

Distribution: - *B. decoloratus* has a wide distribution in Africa, being from west to east and north to south part of Africa. Undoubtedly the predominant hosts are cattle, although horses and less frequently man, sheep and goats are infested. Of the wild fauna antelopes are some frequently attacked, but records from hares, zebra, bush pig and buffalo are noted. Carnivores appear to be rarely attacked by this species (Hoogstraal, 1956).

It transmits *Babesioses, Anaplasmosis* and *Spirochetosis* of cattle, sheep, goats, horses and swine in east Africa. In all instance the infection passes through the eggs to new generation of tick (transovarial transmission). Cases of acute anemia in hosts have been reported as a result of the feeding activities of this tick species and it has been implicated as a vector of *Babesia bigemina* (Texas or red water fever) and *Anaplasma marginale* (gall sickness) in cattle and of *B. theileri* (Spirochaetosis) in horses, sheep and dogs.

Life cycle: **-** *B. decoloratus* is a one-host tick, the female lays 2 500-4 000 eggs, that hatch between 14-145 days. The parasitic period on the host ranges from 17-52 days.

Seasonality: - In those localities with rainfall most of the year, *B. decoloratus* females were abundant from end of rainfall peak to beginning of the rainy season. Nymphs were mostly collected during beginning and end of the rains. In localities of summer rain, *B. decoloratus* females were absent from collections before and after the rain. Nymphs were absent during the dry season. These two instars appear to be mostly present in collections of the beginning of the rainy season (Lima *et al.,* 2000).

Common hosts: - *B. decoloratus* feeds on cattle, horses, bushbuck and kudu. *Zebu* cattle are less susceptible.

The distribution pattern of *Boophilus decoloratus* is similar to that of *Amblyomma variegatum*. It was the second most abundant tick species recorded and together with *A. cohaerens* the most abundant on cattle (Kaiser, 1987). In previous records, *Boophilus decoloratus* was collected between 1200-2400 m altitude and at 1000-2400 mm rainfall in both rainfall modes and was predominate in broad-leaved and coniferous forest areas (Gray and Potgliter, 1982). In the present survey, *Boophilus decoloratus* was recorded from all altitude zones where ticks were collected. It predominated between 1600 and 2400 m but it was present in some of the collection sites between 400-600 m. It was also present in all rainfall zones, being most common between the 1400 and 2200 mm isohyets and in both rainfall modes. It was found in all climate climax types (Mekonnen *et al.,* 2001).

2.2.3.2.2. Amblyomma cohaerens (Donitz, 1909; Hoogstraal, 1956)

General:- The *Amblyomma* ticks are frequently called the bont ticks. Bont is the African word referring to the presence of brightly colored patterns on their backs and their brown and white-banded legs (Donald, 1981; Solomon and Kaaya, 1998). Two different types of *A. cohaerens* have been observed in Ethiopia. A larger type believed to be associated to wild hosts, particularly African buffalo and a smaller one from cattle.

The second type has adapted from buffalo to cattle and most common in Ethiopia. In western Ethiopia, where the climate is humid for much of the year, *A. cohaerens* is the most prevalent and abundant tick on cattle. Previous records from the western zone, *A. cohaerens* have been found between 1200-1800 mm rainfalls in both rainfall types. It was collected from areas of broad-leaved forest (Pegram *et al.,* 1981).

In the present survey, *Amblyomma cohaerens* was recorded from all altitude zones but it predominated between 1600-2400 m. It was recorded between 800 and over 2600 mm rainfall although it was absent from the rainfall zone between 1000-1200 mm, probably due to chance (Mekonnen *et al.,* 2001).

Life cycle:- *A. coherence* is three-host tick, female produces up to 20000 eggs that hatch between 4-13 weeks, depending on the circumstances. The larvae engorge 4 -20 days and molt in 2 -7 weeks. The nymphs engorge in 5-20 days and molt in 14-60 days. Adult females engorge in 10-20 days.

Seasonality:- In those localities with rainfall most of the year, *A. cohaerens* females were mostly collected before and during the rainfall peak and less collected after the rainfall peak. Nymphs were mostly collected just before the rainfall peak and were less common during the rains. Larvae were most before the rains. In localities with summer rains no variation of the instars were seen (Castro, 1994).

Common hosts:- *A. coherence* feeds on many species of mammals, rarely on birds. Predilection site: udder, perianal and genital regions. The bites of *Amblyomma* ticks are severe. It may result in septic wounds and abscesses, inflammation of the teats of cows and considerable damage to hides and skins. The tick is the main vector of the rickettsia, *Cowdria ruminantium,* which causes heart water disease. It is also associated with an increase in the prevalence of acute dermatophylosis, a skin disease of cattle caused by the bacteria *Dermatophilus congolensis* (Jongejan and Uilenberg, 1994). In western Ethiopia, acute dermatophylosis is the major cause of economic loss resulting from ticks.

2.2.4. Pathogenic effect of ticks

2.2.4.1. Cytolysis effects

The primary attachment lesion causes cytolysis following production of the hyaline sheath. There is itching accompanied by a tissue and humoral reaction of the host, with hyperemia, eosinophil infiltration and a local edematous reaction. The damaged tissues are pulled by the weight of the feeding tick and this produces a sensation of pain (Morrisan, 1989).

The salivary glands of ticks perform numerous vital functions. They secrete cement that anchors the mouthparts to the skin soon after the tick attaches to the host. The salivary glands are the major organs of osmoregulation and possess a water vapor uptake mechanism that enables ticks to fast for many months. During feeding the salivary glands of the female secrete excess fluid from the blood meal back in to the host's circulation, thus concentrating the nutrients components of the meal and regulating hemolymph volume and ionic composition. These factors lead to the reaction of the host.

The primary challenge or infestation: when ticks attach to a host (primary infestation), they secrete cement and other antigenic materials. In the guinea pig, 40-60 % of the leucocytes infiltrating the lesion are neutrophil, up to the third day of feeding. A day or two later when most of the larvae have engorged, the proportions of basophils and eosinophils have increased significantly.

Early in tick attachment, the capillaries near the mouthparts become dilated and edema results. This is probably due to vasoactive substances, in tick saliva such as prostaglandins, and to a few degranulated mast cells which release histamine. Hemorrhage is an obvious characteristic of the feeding lesion. Finally, the langerhans cells of the epidermis trap antigenic material from tick saliva and present it to lymphocytes in the skin and lymph nodes for processing.

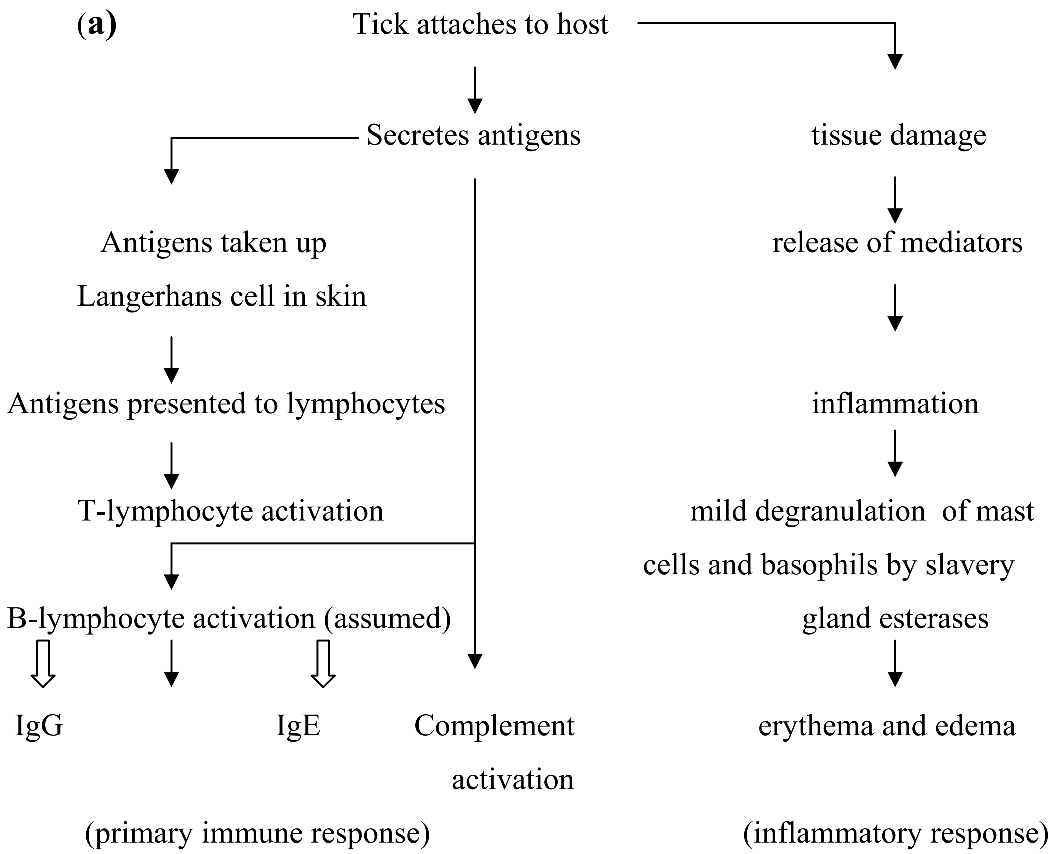

Figure 7. Host reaction to tick challenge by primary infestation (Morrisan, 1989)

(a) Reactions to a primary infestation. Other than a mild inflammatory response leading to erythema and edema, there are few obvious clinical reactions. The specific immune response involves the activation of T-and B- lymphocytes.

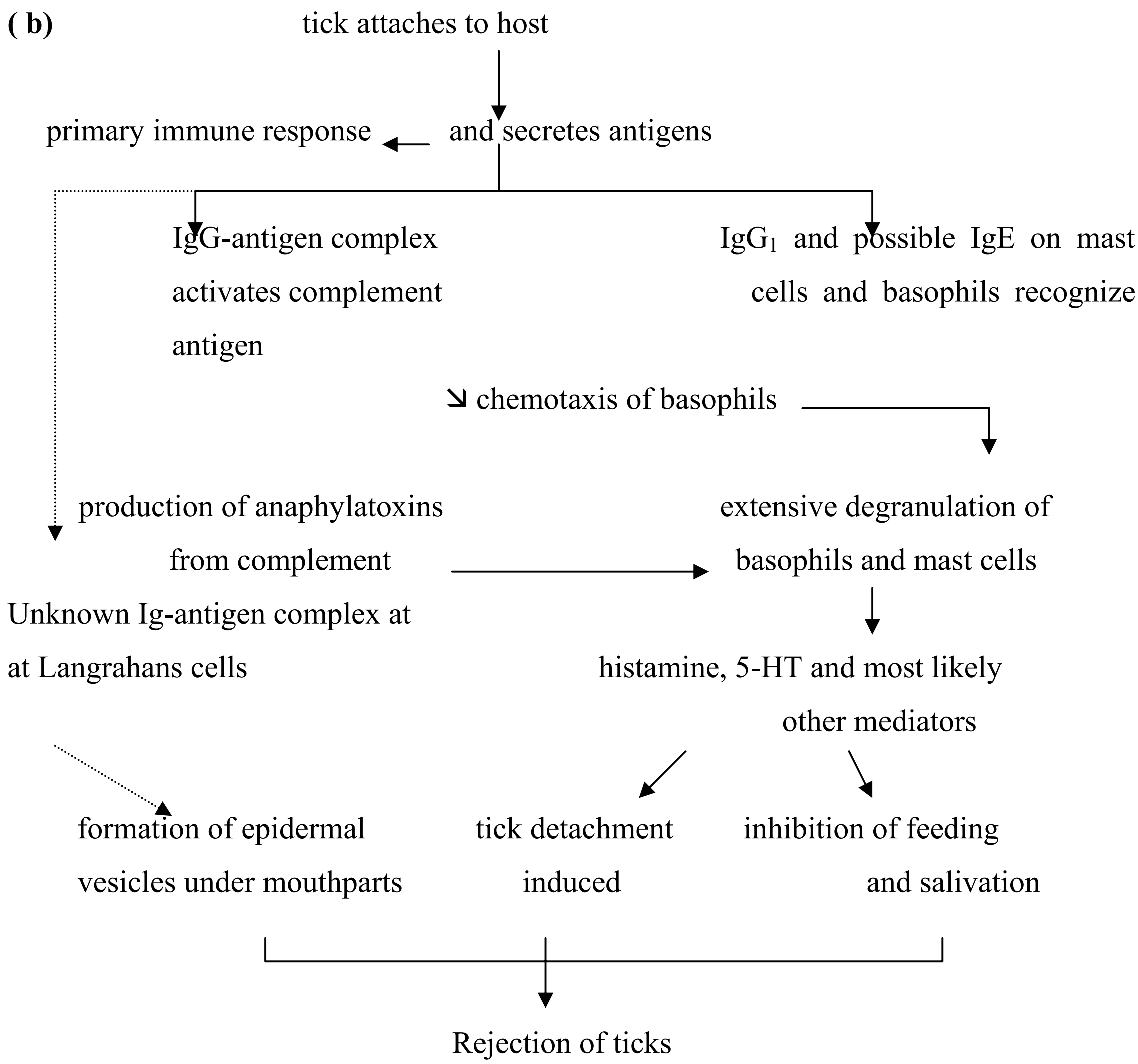

Figure 8. Host reaction to tick challenge by secondary infestation (Morrisan, 1989)

(b) During a secondary infestation, mast cells and basophile degranulation and the release of mediators are much greater than during the primary infestation, leading to rejection of ticks.

Sensitized host: Hosts that have endured a primary infestation are known as sensitized hosts. A prime, if not very specific, indicator of sensitized hosts is an increase in peripheral basophils and eosinophilia.

Secondary challenge or infestations: During secondary infestation, the granulocytes in the peripheral blood rise to much higher levels than during the primary infestation and basophils rapidly invade the feeding lesion, degranulate and liberate vasoactive mediators. The later cause edema and might contribute to the formation of blister-like epidermal vesicles underneath the attached ticks. Histamine 5-HT inhibit feeding and salivation, the histamine may induce detachment from the host. Premature detachment and much reduced engorged weights may result and those ticks that do not detach feed very slowly, if at all, and most die *in situ*.

As a result of the laceration of blood vessels by the probing actions of tick mouthparts, the host's circulatory homeostatic mechanisms begin to act and in response to these, ticks release salivary secretions to maintain blood flow to the feeding lesion. However the salivary composition of a particular species may be a partial determinate of effective host range. Thus, ticks that posses antihistamine salivary activity probably feed successfully on basophile-rich hosts (cattle, guinea-pigs, rabbits) but may be rejected more effectively by mice, which rely on bradykinin and anaphylatoxins as vasoactive mediators (Bianchi *et al.,* 2003).

After detachment of the tick the necrotic lesion remains indurate, itching, and hot, and can discharge for several months. Bacterial complications may set in with abscess formation. The hypostome may break and remain in the lesion when a tick is extracted. In receptive cattle, the tick remains in place, and lesion is formed with eosinophil infiltration around the necrotic patch near the chelicerae. The allergic reaction is sign of host resistance (Tatchell, 1969).

2.2.4.2. Cell reaction

The lysis cavity opens into internal tip of the sheath, and is formed of amorphous necrotic tissue, with cutaneous and blood cell debris. An edematous zone surrounds the lysis area when the cell structures gradually disappeared collagen remains intact and extravasations and vascular ruptures occur, with hemorrhagic patches. In receptive hosts, the main phenomenon is neutrophil infiltration around the attachment point and capillaries. The resulting inflammation produces vasodilatation, vascular ruptures, and hemorrhages near lysis cavity, while the surrounding dermis becomes fibrous due to the multiplication of fibroblasts. The other cells degenerate at the same time. The dermis and epidermis become edematous. Vesicles and necrotic zones appear at the end of the attachment process, in the presence of eosinophils and basophile. In the receptive host, the main phenomena are vasodilatation and vessels rupture (Allen, 1994).

In resistant hosts, tissue reactions are more violent and occur earlier. They are dominated at first by considerable edema of the epidermis and dermis, accompanied by eosinophil and basophile infiltrations from the second day of attachment. Cell decomposition and tissue necrosis are rapid and extensive, but there are not many capillary ruptures. The vesicles appear very early and develop in to pustules. Although the tick saliva has a limited lysis effect, it causes inflammation through degranulation and high antigenic activity. The ingested blood is concentrated by excretion of water and mineral salts starting from the beginning of the meal. Highly engorged species therefore ingest about three times the volume of blood at the end of the meal (Uspenskiy, 1982).

2.2.4.3. Toxic effects (tick toxicosis)

Apart from the mechanical cytolysis effect and blood loss, ticks have a specific pathogenic effect due to the presence of toxins in the saliva. The toxins affect not only the attachment site but also the entire organs of the host. The toxins act on certain tissues. Neurotropic toxins induce tick paralysis, while dermotropic toxins cause sweating sickness (Tatchell, 1969; Allen, 1979).

2.2.5. Control measures for ticks

2.2.5.1. Steps of a controlling campaign

The aim of a tick control campaign is not to control all ticks simultaneously, but a definite species because of its particular role. The strategy should therefore be based on the biological characteristics of the target species. Moreover, there is no perfect control method. The efficacy of these methods depends on rational and methodical use (FAO, 1977; Jongejan and Ulenberg, 1994).

Factors to be defined when a campaign is planned against ticks:-

a) Campaign objectives: The objectives must be defined on the basis of the biology of the species and epidemiology of the disease caused or transmitted by the particular tick species. Temporary or regular deparasitizing of infested animals is a short-or medium-term measure. It provides relief for the host, but does not affect ticks in pastures. Reduction of tick populations in a pasture has long-term prophylactic effects as it decreases parasitism and frequency of pathogen inoculation to a tolerable level. Premunition is established or maintained by regular treatments on fixed dates or occasional treatments when the parasitism rate exceeds a certain level. Eradication of ticks has a long-term prophylactic effect and controls transmission of a particularly dangerous pathogen (Kaaya, 2003).

b) Target location: A site is selected for the campaign from the different successive microhabitats of a tick in its free-living phases, and during the parasite phases on the host. The selection is based on ecological data. The control operations are carried out in the field and on the host. In the field, the objective is to attack ticks in their microhabitat during the free-living phases by chemical or ecological measures. On the host, the aim is either to rid it directly of its parasites, or indirectly by means of hosts that collect ticks and serve as bait. This enables long-term deparasitizing of pastures, which is the final goal (Okello et al., 2003).

c) Campaign schedule: Information on dynamics is useful for determining the pattern of host treatments and suspension of treatments during seasons of inactivity, on the basis of the life cycle and duration of the parasite phase during seasons of tick activity. In methods requiring removal of livestock, data on survival possibilities of the various instars without feeding will determine how long cattle should be excluded from the pastures. The period required for completion of the cycle should be considered, in the case of species with certain instars that develop on hosts other than ungulates or on wild vertebrates for a part of the tick population (Jongejan and Ulenberg, 1994).

2.2.5.2. Types of tick control

Tick biology data are fundamental factors in chemical control and represent a method in biological control. The two control methods differ only in the use of acaricides. Procedures directly affecting the microhabitat and host availability such as using hyperparasites and predators, and immunological control form a part of an integrated biological control program. The practical importance of these methods varies. Some are effective on their own, but it is important to combine them. The use of acaricides is inconceivable without data on the natural environment of ticks and their hosts (Kemp, 1994).

2.2.5.2.1. Chemical control

Acaricides are needed to control tick infestations and tick born diseases. However, the use of acaricides is constrained by their high costs, tick resistance, concerns about residues in food and in the environment (Pegram *et al.,* 1991; Mekonnen, 1996). Consequently, the intensity of application of acaricide will depend on whether the aim is to prevent disease transmission or to reduce tick damage and /or worry. Thus a choice can be made as to whether to adopt intensive or strategic/threshold acaricide application or other systems (Kemp, 1994).

The various chemical compounds used in controlling ticks are either natural or purely synthetic. Acaricide applications on the ground or on the host dip, spray, powder, ointment, pour-on preparations require data on the location and necessary treatment pattern. The efficacy of an acaricide depends on rational and careful use. The fact that acaricides are toxins should not be overlooked when extending sometimes imprudently their use, even if they are more harmful to arthropods than to warm-blooded vertebrates. However, fish, amphibians, and reptiles are very sensitive to a number of acaricides (Okello *et al*., 2003).

Different acaricides have variable effects on different tick species. It may have weak, satisfactory, good, or excellent effect. But there is no one that gives immediate results without the need for a long-term eradication campaign strategy. Changes in numbers of ticks on the cattle should be evaluated one year after the start of the treatment. If there are no definite qualitative or quantitative changes in the tick population in the following year, other causes that may reduce or counteract the effect of acaricides should be investigated (Kagaruki, 1991). Acaricides are used in different ways to control parasites of domestic animals. The selection of the method depends on the host species, target parasite, size of the animal population and type of acaricides. The objective of the user private owner, cooperative, public service at community or territory level is also important and depends on the type of production system sedentary or transhumant animal production.

2.2.5.2.1.1. Ways of application

The operations and equipment range from simple individual wetting with a sponge to the most elaborate dips and spray races. They can be broadly classified as cutaneous or systemic according to the technique or route of application:

- Cutaneous treatment: dip, low or high-pressure spray and dusting
- Systemic treatment: transcutaneous, subcutaneous and oral route.

The selection of an appropriate procedure for treatment on the host depends first on economic considerations; other considerations are the type of acaricides, location, and parasite susceptibility (Hadani *et al.,* 1967).

2.2.5.2.1.2. Precautions for acaricide treatments

The animals should be inspected before dipping, since certain individuals may not require any treatment or the application conditions may need to be modified. Many accidents occur, not only from acaricide toxicity, but because the animal is not well enough to tolerate the treatment. The recommended doses have a large safety margin, but a weakened animal becomes more sensitive to any toxic substance. Animal factors that should be considered before the treatment:

- Age: Newborn, young, and adult animals should be separated. Newborn animals under two months should not be treated.
- Size: Size is related to age, and it is important not for toxicity but because mass and strength can reduce the risk of being crushed during jostling.
- Pregnancy: Females in the last third of pregnancy should not be treated by a group method. Individual treatment may be carried out after taking certain precautions (lower concentration, selective application).
- Lactation: Lactating females may be dipped, but the young should not suckle for three hours following dipping.
- Lesions and wounds: Lesions and wounds are sites for heavy absorption of toxic substance. Such animals should not be treated, especially if the wounds are recent.
- Fatigue: Fatigue reduces resistance and may lead to resurgence of special acaricide sensitivity. Increased circulation near the skin causes the pores to dilate, so that more toxic substance is absorbed. The animals should rest for several hours, particularly after a long trek to reach the treatment center.
- Hunger and thirst: Hunger and thirst should be satisfied to calm the animal, remove fatigue, and especially prevent it from wanting to drink while it is in the acaricide dip.
- Atmospheric conditions: The aim is to avoid the risk of chills after wetting, the effects of which could be disastrous for a herd. The treatment should be carried out when conditions are most favorable for drying and fixing of the acaricide on the hair and skin (Young et al., 1988; Mekonnen, 1996).

The animals should preferably be dipped in the morning, so that they have time to dry during the day. When the treatment is scheduled just before nightfall, the animals should be sprayed and not dipped. In cool weather, treatments should be carried out late in the morning, just before the hottest part of the day. In the cold season, dipping or spraying should be replaced by dusting if necessary. Treatments in bright sunlight or during the hottest part of the day are not recommended. The time to be chosen is the morning or the cool part of the afternoon to avoid thirst and cutaneous vasodilatation. Optimum temperature is between 18 and 20^{o}C. Dipping should be abandoned if there is a probability of rain, as this would wash the acaricide off the animals (Latif, 1984).

2.2.5.2.1.3. Chemical tick control in Ethiopia

The conventional method of controlling tick infestations in Ethiopia is application of acaricide, by hand spraying, by hand dressing or using spray races. Traditional tick control methods such as hand picking, burning with a hot iron or application of plant juice are also used in rural areas. The acaricides available in the country are:

- Chlorinated hydrocarbons groups: toxaphen (Coopertox®, Cooper®), CHC (Lindan®, Gamatox®), HEDD (Dieldrin®)
- Organophosphorus group: quintiofos (Bacdip®, tick grease®), dioxathion (Bercotox®), and chlofenvinphos (Steladone®), used on indigenous zebu cattle, with occasional treatment on *Amblyomma* feeding sites such as udder and scrotum.
- Carbamates group: carbaryl (CBM-8®), used mainly by private dairy farms where crossbred cattle are kept and acaricide application is irregular
- Cyclic amids: Cymiazol (besuntol®) Amitraz (Norotraz®)
- Avermectins: Ivermectin (Ivomec®)
- Synthetic pyrethriod group: flumethrin (Bayticol®, pour on®) and deltamethrin (Spot-on chemicals, used intensively in state dairy farms where exotic and crossbred cattle are kept (Mekonnen, *et al.,* 2001) table 4.

At present, the government has no direct control or registration requirements on the importation and use of acaricides. To address this problem the ministry of Agriculture has drafted a policy on acaricide registration, importation and utilization, which has been submitted to the government for approval. It is a government responsibility to monitor the use of potentially dangerous chemicals and conserve foreign exchange (Mekonnen *et al.,* 2001).

Chlorinated Hydrocarbons (CHCs)

Chlorinated hydrocarbons are all liposoluble; this characteristic makes them soluble in the lipids of the cuticle and body of ticks. The route of introduction is usually cuticular or cutaneous and leads to nervous symptoms. The biological activity of CHCs destroys the nervous system of living organisms. The principle of the poison is not clear in detail. After oral and pulmonal intake, toxicity is at its highest. Because of the lipid solubility of the compounds, food rich in fat (milk) increases the toxicity; equally oily solutions are reabsorbed rather quickly after dermal application. Since the compounds are deposited in body fat, thin animals can easily become poisoned; fat animals fall ill if they use up their fat deposits during periods of extreme hunger and thus release the poison.

Chlorinated hydrocarbons are very stabile in the environment, and their catabolism within the organism is rather slow, depending on their composition. Chlorinated hydrocarbons are also eliminated through milk and eggs. As tissues can also fix them, they should be used with extreme caution when treating animals intended for immediate slaughter, dairy cows, or laying hens.

Table 4. Ways of application and concentration of compounds used for tick control in Ethiopia (Redley, 1991; Mekonnen, 1998)

Group of compound	Generic name	Trade name	Concentration (%) of active substance and ways of application			Residual effect (days)
			Dip	Spray	Pour on	
Chlorinated hydrocarbons	Toxaphen	Coopertox	0.5	0.75		20-40
	CHC	Lindane	0.75	0.75		30-50
		BCH	0.75	0.75		30-50
Organic phosphorus	Coumaphos	Asuntol	0.1	0.1		7
	Trichlorphon	chlorfos			0.15	2
	Quinthiophos	Bacdip	0.08	0.08		4
	Chlorphenvin-phos	Steladone		0.05		2
	Dioxathion	Cattle dip	0.06	0.05		4-7
	Malathion	Malathion	0.05	0.15		2
	Famphur	Famophos			2.6 mg/kgbm	4-7
Carbamates	Carbaryl	Vioxan		0.2		
Pyrethroids	Flumethrin		0.5	0.5	0.75	30
Cyclic amidins	Cymiazole Amitraz	Besuntol Norotraz	 0.25	0.03 0.25		7 7
Avermectines	Ivermectin	Ivomec			10ml/50 kgbm	14

Kgbm= Kilogram body mass

Organo-Phosphoric Acid Esters (OPAEs)

Organophosphates are highly liposoluble, but are also water soluble to a certain extent, unlike chlorinated hydrocarbons. Organophosphates compounds have low stability in the system of warm-blooded animals. They are rapidly metabolised and are usually eliminated within a week following treatment. Organophosphate compounds are phosphates, phosphonates, phosphothionates, phosphothiolates and phospodithiolates. They inhibit the cholinesterase that is the enzyme that split acetylcholine, the transmitter of the synapses between nerve cells and muscles into acetate and choline. These compounds have an effect on the nervous system of the arthropod as well as on the nervous system of warm-blooded animals.

Depending on the formulation, most products are easily absorbed after dermal, parentral and oral application. Therefore, they are suitable for use as contact pesticides or as systemic acting substances. During metabolization, part of the active substance may be deposited for a short time within the fat before it is excreted with the milk and fat. This part of the substance is not involved in the systemic action. The advantage of OPAEs over CHCs is that they are biodegraded in a short time within the environment.

Carbamates

Carbamates are esters from carbamic acid. Biologically, carbamates also inhibit cholinesterase. They bind with the active centers of the cholinesterase and block the hydrolysis of the acetylcholine. The effect of carbamates on arthropods already appears 1-30 minutes post application depending on the compound and the form of application. The transmission of stimuli and impulses of the nervous system is interrupted, and after a phase of uncontrolled movements that are followed by paralysis, death supervenes. Domestic animals hardly ever absorb carbamates dermally. Carbamates are metabolized through oxidation of the phenyl nucleus and of the N-ethyl group and through hydrolysis. The metabolites are exhaled as Co_2 or excreted with urine, faces and milk; it is less toxic for warm-blooded animals.

Pyrethroids

Pyrethroids are etheric oils and they are synthetic esters from chrysanthemum acid or its derivates with both an acaricidal and insecticidal action. The chemical structure is similar to that of natural pyrethrins that are substances contained in Chrysanthemum species, which have been derived from chrysanthemums for a long time. In contact with the arthropod, pyrethroids have a significant knockdown effect. Through contact with the active substance, the ion exchange at the axon of the nerve of the arthropod is blocked which causes an interruption of the nerve transmission. The effect on the nervous system of the arthropods does not recover. Even with low dose, a tick's oviposition is inhibited. Pyrethroids have a low toxicity for vertebrates: neither neurotoxic nor mutagenic effects are to be found.

Cyclic Amidins

Cyclic Amidins belong to heterogeneous group of compounds. It interfere with the metabolism of ticks, reduce the glycogen and glucose level and block the development of the ova, affect respiratory enzymes by blocking the NADH-fumarat-reductase and cause neuromuscular blockage also known as tick detaching agent.

Avermectins

Avermectins are products of the fungus *Actinomyces* species that are divided into two major components A and B depending on the structures. Avermectins compound is active against intestinal parasites, lungworms, warble flies, lice, midges and different genera of ticks. The active substance inhibits the transmission of stimuli between the interneurons of the ventral nerves and the motor neurons of the parasites. The compound is deposited for a short time in the liver, fat and only in small amounts in muscle and kidney. About 50% is excreted unchanged with the faces. Therefore, a withdrawal time of 38 days is required for milk and beef. Because of this, it also does not make sense to utilize the compound in tropical animal production (Seifert, 1996).

2.2.5.2.2. Ecological control

Information on the ecology of different instars is used for habitat and host linked treatments. Tick control in the habitat and vegetation requires modification of the plant cover by removal of vegetation that shelters ticks. Vegetation is periodically removed by burning, but spontaneous or induced fires have little direct effect on ticks since they occur in the season when adults are not active. Annual dry-season fires are widespread in semiarid regions; the value of these fires is very controversial, as they influence not only the availability of an important source of grazing during long harsh dry seasons, but may also diminish the abundance of ticks and vermin such as rats. The influence of burns on tick abundance varies markedly with the time of year, intensity of burn, and the tick species present (Wilkinson, 1979; Baars, 1999).

Replacement of natural vegetation, cropping, and soil cultivation are integrated methods that enable pasture improvement and tick eradication. Using acaricides, careful plastering of walls and ceilings, and installing concrete floors sanitize localized habitats such as stables, sheds, poultry houses, and kennels and the soil of cattle enclosures, markets, areas around wells, etc.

Wild ungulates and carnivores, as well as other possible hosts of the different instars should be eliminated. Since wild ungulates are alternative hosts and can maintain tick populations as effectively as cattle, their removal is the most effective measure. The objective of briefly or periodically withdrawing domestic hosts is to cause the ticks to disappear through inanition since the only available hosts are cattle. Pasture rotation can be used exclusively, or together with the use of acaricides for this purpose.

The rotation pattern and pasture area should be determined according to the target species, type to cycle, and hosts of the successive instars, as well as the period of stay and number of cattle. Other important factors are the period required for inanition by each instars, periods of tick activity depending on the seasons and type of climate (McCosker, 1979).

2.2.5.2.3. Biological control

Entomopathogens are group of organisms that attack ticks and insects. Entomopathogens can be macro- or microorganisms that affect arthropods. In biological tick control the activities of the hyperparasites *chalcid* flies *Hunterellus* are probably important in nature, but they are difficult to evaluate. It is still more difficult to manipulate or reproduce them for practical use. Predators are most effective, especially ants and birds (*Buphagus sp.* or *oxpeckers*, *Crotophagus*, various magpies, village fowl). Depending on the conditions, these predators can consume a large number of ticks (Samish and Alekseev, 2001).

2.2.5.2.4. Genetic control

In resistant animals, the blood level of histamine rises considerably within 48 hours of tick attachment. In moderately resistant cattle, there is only a slight increase in the histamine level when larvae attach; it is higher for nymphs, and even higher for females. In receptive animals, there is no change in the histamine level. Antigens extracted from eggs or larvae give the same results in resistant animals. The reaction intensity is not correlated, however, to the degree of resistance (Willadsen, 1999). Resistance to ticks in animals occurs early but is effective mainly in adults. This resistance can be broken by the occurrence of physiological or pathological disorders. The diseases induced or transmitted by ticks can also reduce resistance and are accompanied by an increase in the animal's quantitative tolerance threshold for ticks, which may lead to sever parasitism, with clinical signs (Willadsen and Jongejan, 1999).

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The ability is a hereditary character. The ability to resist ticks is acquired, but it develops according to genetic factors. If it is possible to breed cattle for tick resistance, as is done for certain other characteristics, it will provide a solution allowing the costly and dangerous use of acaricides to be abandoned, with the related risk of the emergence of non-sensitive tick strains. The question remains whether breeding for tick resistance can be compatible with breeding for a particular production characteristic (meat, milk) (Brown and Askenas, 1982).

2.2.5.2.5. Immunization (anti-tick vaccine)

Research in to controlling cattle tick *Boophilus microplus* has focused on developing vaccines; cattle vaccinated with antigens from the midgut of female ticks were protected from challenge with *B. microplus* (Opdebeeck *et al.,* 1988; Willadsen *et al.,* 1988). Ingestion of the blood meal by ticks feeding on vaccinated cattle leads to uptake of antibodies and other components of the host's humoral immune system, resulting in damage to the gut. As a result, the number of ticks engorging, their average weight and their ability to lay eggs may all be adversely affected.

Australian tick control project develop a vaccine against *B. microplus.* It was commenced in 1981 with the observation of the cattle, vaccinated with crude or partially purified material from semi engorged adult female ticks, could be effectively protected against tick infestation. The major antigen responsible for this effect, called Bm86, was isolated 4 years later. The antigen is located on the surface of the digest cells, which line the tick's gut. The feeding tick takes in antibody to Bm86. Binding of antibody to the protein on the tick gut leads eventually to lysis of the tick's gut cells. The number of ticks engorging on vaccinated cattle is reduced tick weight and even stronger reduction in the ability of the female ticks to lay eggs. In fact, there is considerable mortality of engorged ticks in the first days following engorgement. The antigen has been sequenced and expressed in *Escherichia coli* or *Aspergillus nidulans* (Willadsen *et al.,* 1989; Tellam *et al.,* 2002).

This recombinant tick vaccine was registered for commercial sale in Australia in 1994, called "Tick Guard®". With this vaccine over 18000 cattle had been vaccinated in northern Australia. In a variety of tests of efficacy and safety it was shown that the vaccine was completely safe for use, effective in a variety of different geographical locations and effective against a wide range of ticks that were resistant to the different classes of chemical acaricide. It was found that there were some differences in the vaccine susceptibility of different isolates of tick for reasons, which are not understood. It was further shown that a range of different cattle breeds responded to the vaccine in equivalent ways, as measured by antibody responses following vaccination (Willadsen, 1997).

The effect of vaccination with Bm 86 vaccine "Tick Guard®" plus resulted in 56 % reduction tick number in the field over one generation and 72 % reduction in the laboratory. The live weight of vaccinated cattle over 26 weeks was 18, 6 kg higher than control and lower somatic cell count in milk (Johnson *et al.,* 2000).

Another recombinant vaccine "Gavac®" also produced in Cuba has large-scale production using the yeast *Pichia pastoris*. The vaccine was registered in Cuba in 1993. In field condition Gavac® vaccine control *B. microplus* population in grazing cattle. A combination of chemical acaricides and vaccination in Colombia and Brazil represented 57 % reduction in the number of treatment in a year (Canales *et al.,* 1997)

2.2.6. Procedures of tick collection, preservation, and culture

a. Collection

The entire body surface of the host must be inspected for ticks. They are also found inside the ear, at the base of the mane, inside the tuft of the tail, and in interdigital spaces. Ticks large enough to be grasped with fingers are withdrawn gently by pulling firmly in the opposite direction as they are attached.

All the ticks should be collected, unless there are a large number of engorged females or nymphs as it would then be very laborious. It is better to detick a few animals completely than to take a few specimens from many animals. Unfed ticks can also be taken from the soil surface, in caves, burrows, nests, and similar places (Nicholson, 1983). Engorged females or nymphs may be kept alive for morphological identification of hatched adults, larvae or biological studies. Engorged ticks are placed in container half filled with crumpled or shredded filter or blotting paper, but not cotton wool. The container is plugged with cotton wool that is pushed in until it touches the paper. This protects the tick during transport. The live specimens are labeled and packed in the same way as the preserved specimens (Nicholson, 1983; Pegram *et al.,* 1987).

b. Preservation

There are two preservatives that are used most frequently. The possibility to store ticks in 70 % ethanol is of great advantage and makes transport samples cheap and easy. It fixes and preserves very well and does not harden the tegument, but dulls some enamel colors. Methylated spirit may be used if alcohol is not available but it makes the specimens brittle, although it fixes and preserves them very well (Morel, 1989).

The second 6 % commercial formaldehyde also fixes and preserves very well, especially the colors, but it hardens the tissues. Adding glycerin 3-5 % can solve this problem. During the first preservation, the bulk of the specimens should not exceed half the volume of the receptacle (flask, tube) if the ticks are unfed or not very engorged. If they are engorged it should not exceed one-third of the volume. The excess water in their bodies lowers the concentration of preservative and may lead to maceration and sometimes putrefaction of the specimens. If there are many ticks, they should first be left in alcohol for 2 days. The alcohol should then be replaced completely (Nicholson, 1983).

c. Records

A record card for a collection should include information on the exact place of collection including the coordinates; the host and exact number of hosts in the case of a wild species (or the carcass, skin, head, or any other part, should be sent for identification) with the location if it is unusual; date of the collection; and all possible information on frequency, abundance, and other relevant details. Specimens collected from the same herd on dates at more than 1-week intervals, or from herds more than 1 km apart, should not be mixed. Ticks from hosts of different domestic or wild species in the same pastures, should also not be put together (Sutherst and Dallwitz, 1979; Morel, 1989).

d. Packaging and Labeling

Labeling consists of placing some form of identification on the collection. This may be a reference number for the record card, but a label indicating the place, date, and host is preferred. The label should not be stuck on the container as it may come off. Therefore, the label should be put inside the container with the ticks. It should be made of strong paper or thin card. The entries should be made with Indian ink or pencil, but not ballpoint pen. Containers must be properly sealed and placed in paper, sawdust, or foam padding. When record cards are included in the package, they should be put in a polythene bag to prevent them from getting wet with alcohol or formaldehyde, or spoiled if the container should break open. Post parcels should be labeled "Scientific specimens of no commercial value" (Nicholson, 1983; Morel, 1989).

e. Cultures

Cultures are made in specialized laboratories. The ticks are maintained in an incubator under humid conditions for the different phases of the cycle oviposition, embryogenesis and metamorphoses. The ticks are fed on various animals including rodents, hedgehogs, poultry and cattle. They are shut in capsules and placed on the skin surface, which may or may not be shaved. If small animals are used, they are placed for 12 hours in a box with unfed ticks, and then kept in a metal cage placed on a water-filled tray. The ticks are recovered from the tray or water surface. If the laboratory hosts are bigger, the ticks are put in bolting-cloth bags that completely cover the ears or scrotum (Nicholson, 1983).

2.3. Tick-born diseases

2.3.1. Characteristic features of tick born diseases

Depending on the pathogens involved and the susceptibility of local cattle, economic losses due to ticks' loss of condition and productivity, morbidity and mortality may represent up to 20 % of the value of the livestock for babesioses and up to 40 % for theilerioses.

The successful transmission of a pathogen by a tick species under laboratory conditions does not confirm that the species is involved in the epidemiology of the disease under natural conditions. It provides a hypothesis, which must be related to the extent to which the experimental cycle corresponds to the natural cycle. The biological characteristics of some pathogens are adapted to transmission by ticks with a particular life cycle, but are incompatible with other kinds of cycles. An exact understanding of the type of life cycle of a tick species is indispensable for interpreting its role in the natural circulation of a pathogen, and for organizing an effective campaign against the vector (Gebreab, 1983).

2.3.2. Distribution of the major pathogens

Tick born pathogens range depends on critical limits between climatic or vegetation zones. Within each area of distribution of a vector, the pathogen is considered as present from the point of view of epidemiological risks. From the point of view of vegetation, this corresponds approximately to the limits between the north and south Sahelian steppes. These areas correspond to the potential spread of *Babesia spp., Theileria mutans, Anaplasma spp.,* and *Cowdria ruminantum* of cattle (Castro, 1994).

2.3.2.1. Babesioses (Red water, Texas fever, Malignant jaundice)

Babesioses is a virulent, inoculable, non-contagious infectious disease that affects most domestic and wild mammals. Its causative agent is a sporozoa of the genus Babesia that is obligatorily transmitted after cyclic development in ticks. The pathology is characterized by a primary parasitic hemolytic anemia giving rise to haemoglobinuria icterus, and by a state of shock often accompanied by capillary thromboses. Splenomegaly is always present with soft pulp and depends directly on the severity of haemolysis (Chartier et al., 1989; Willadsen, 1999).

Babesia - tick relations

These relations determine infection of ticks, and the infectivity of the following instars or generation. Quantitative data on the possibility of infection of Boophilus microplus by Babesia bigemina is available and can serve as an example. In heavy parasitaemia (over 100 %), 90 % of Boophilus females die within 7 days due to multiple intestinal lesions caused by successive sporoblast formations in cells of the digestive epithelium. Survivors have only reduced vitality with reduced oviposition. They are no longer important in determining the infection percentage of population. In low parasitaemia (below 10 %), 5-25 % of the females and 5 % of the larvae of the following generation are parasitized. Infection is maintained through subacute attacks or mild relapses (Gray and Potgliter, 1982; Chartier et al., 1989).

Variations in the Babesia infection rate in ticks and the percentage of engorgement of ticks on the host are related to several interdependent factors. At each critical stage the tick population is reduced including the number of infected ticks. Hence there may not be a possibility of infection or reinfection of the host by Babesia, and for the establishment and maintenance of its premunition. The size of a population therefore determines the frequency of infective bites. The capacity to block the appearance of clinical attacks forms the internal frontier against the disease, and this depends on the quality of the immune defenses (Tatchell, 1969).

In latent infections with minimum parasitaemia less than 1 % of the females are infected. B. bovis causes low parasitaemia so Boophilus population is infected at a much lower rate than by B. bigemina. The breakdown of defenses against ticks during clinical attacks is favorable to the maintenance of an epidemic, since it enables a greater number of ticks to become infected.

The Babesia cycle in Boophilus offers ideal conditions for infection and reinfection. The largest number of females of the Boophilus species is found on infected cattle, since they feed during the clinical attack and at peak parasitaemia. In the case of Babesia transmitted by two- or three-host ticks, however uninfected females are not necessarily present during the parasitaemia following infection by nymphs or infected females, except in the case of heavy infestations (Taylor, 2001).

Tick-host relations

Seasonal variations, the biology of each tick species, and population dynamics determine the activity periods of the vectors on the hosts, and consequently the infection or reinfection periods. The activity period of a given species covers a variable part of the year, depending on the climatic conditions. Babesia development in the vector depends on the life cycle of the tick, mainly the season when the tick is infected and the season when it is infective. The pathogenesis of babesioses differs with the parasite species. In babesioses due to B. bigemina and B. divergens, haemolysis and icterus predominate whereas shock and erythrocyte agglutination are observed for B. bovis. Exotic cattle are more susceptible than the local zebu cattle (Tatchell, 1969).

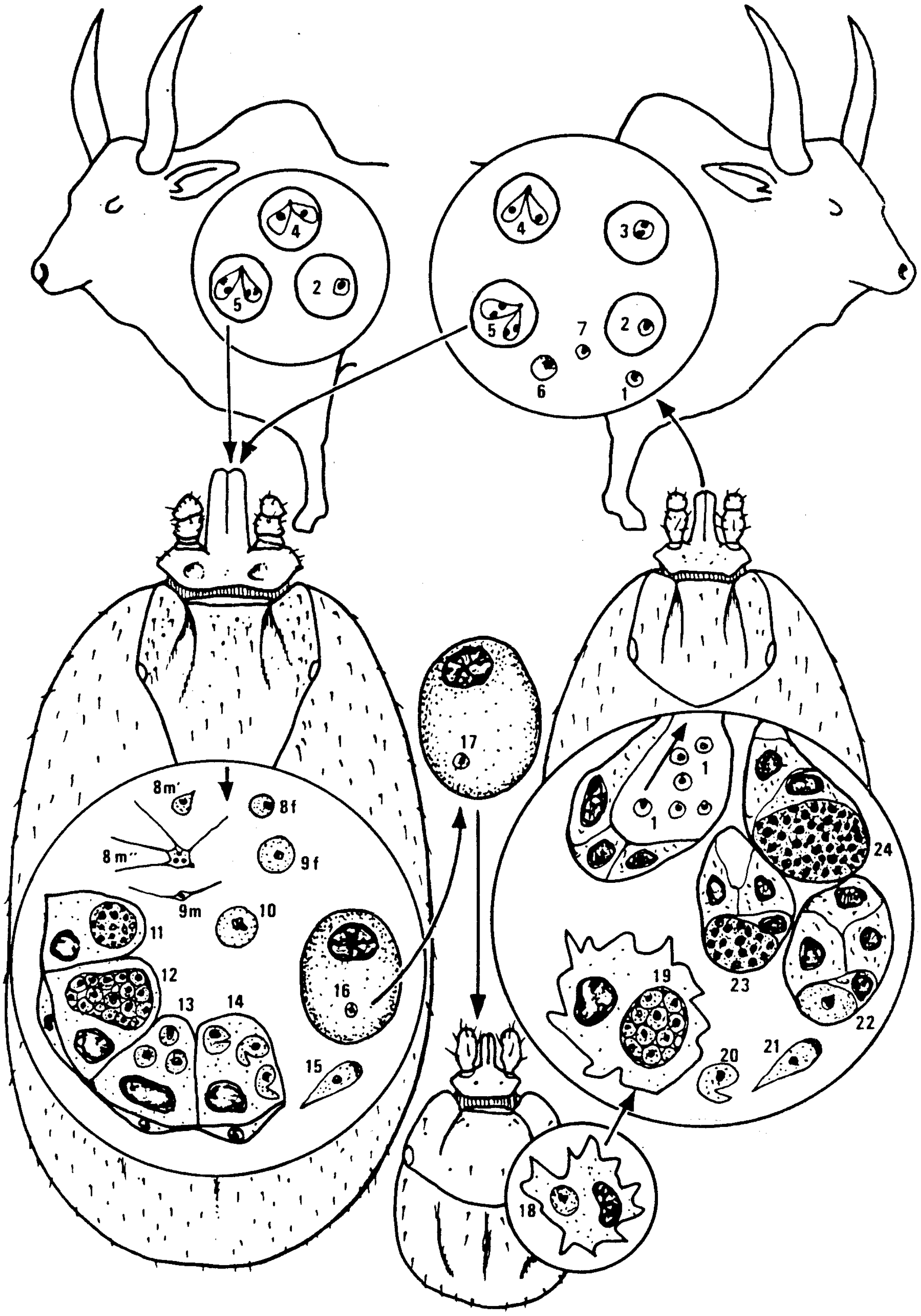


Figure 9. Cycle of *Babesia* in cattle and tick (Chartier *et al.*, 1989)
(refer to key on next page)

In cattle

1: infective metacyclic sporozoite inoculated by the tick

2: trophozoite in the erythrocyte

3: binucleate ovaloid or amoeboid trophoblast

4: bifid schizonts with two uninucleate piriform merozoites

5: mature schizonts with two binucleate piriform merozoites

6: free merozoite after dissociation of the schizonts and destruction of the erythrocyte

7: free trophozoite capable of infecting other erythrocytes

In the engorged Boophilus female

8f: merozoite ingested by the tick and developing into a macrogametocyte

8m: merozoite ingested by the tick and developing into a macrogametocyte by a process of nuclear multiplication and exflagellation

9f: female macrogamete

9m: male filiform microgamete resulting from exflagellation

10: hypothetical zygote that penetrates a digestive cell

11: trophoblast in cell of the digestive epithelium

12: initial intestinal sporoblast producing blastozoites

13: bulbous intracellular blastozoites

14: intracellular blastozoites in the process of elongation by fission

15: club-shaped vermiform blastokinete free in the haemocoel; penetrates various tissue cells, undergoes secondary sporoblasty producing bulbous blastozoites and vermiform blastokinetes

16: blastozoite in an oocyte, which will develop in the succeeding tick generation

In the progeny of the infected female Boophilus

17: blastozoite in the egg

18: intercalary blastozoit in larval haemocyte

19: intercalary sporoblast in haemocyte of nymph

20-21: terminal blastokinietes with salivary tropism in the haemocoel

22: terminal blastozoite in a cell of salivary acinus

23: terminal trophoblast

24: terminal sporocyst producing metacyclic infective sporozoites

2.3.2.2. Theilerioses (East cost fever, Corridor disease)

Theilerioses is an infectious, virulent, inoculable, noncontiguous disease that affects domestic and wild ruminants. It is caused by sporozoa of the genus *Theileria*, transmitted after cyclic development in ticks. *Theileria* species are difficult to differentiate morphologically. They can be characterized using serological methods, and also by their pathogenicity and specificity to different species of domestic animals. The pathology is mainly characterized by a generalized febrile adenitis and edema except East Coast Fever caused by *Theileria parva* demonstrated by high mortality (Chartier *et al.,* 1989; Uilenberg, 1990).

Theileria-host relations

The first part of the *Theileria* cycle, especially in domestic ruminants, takes place in lymphoblasts in the lymph nodes. Peak activity of this phase corresponds to the period of clinical manifestations of theilerioses. Schizogony frequency determines the severity of the disease during the reproductive cycle of the macroschionts with macromerozoites. In nonpathogenic theilerioses, there are few schizogonies of this type. This phase leads to the formation of microschizonts with micromerozoites that continue to develop in the erythrocytes. The schizonts are also called Koch's blue bodies (Tatchell, 1969; Chartier et al., 1989).

Theileria tick relations

Unlike *Babesia*, the *Theileria* cycle in ticks is only possible by transstadial infections during development from larva to adult. There is only one route of tick infection and transmission to the animals. Other infection factors are the same as for babesioses. The blood meal, rather than thermal factors, determines maturation of the oocyst in the salivary gland. Infective sporozoites are realized after a definite period, three days after infection for *Theileria parva* and two days for *Theileria annulata* (Wikel, 1999).

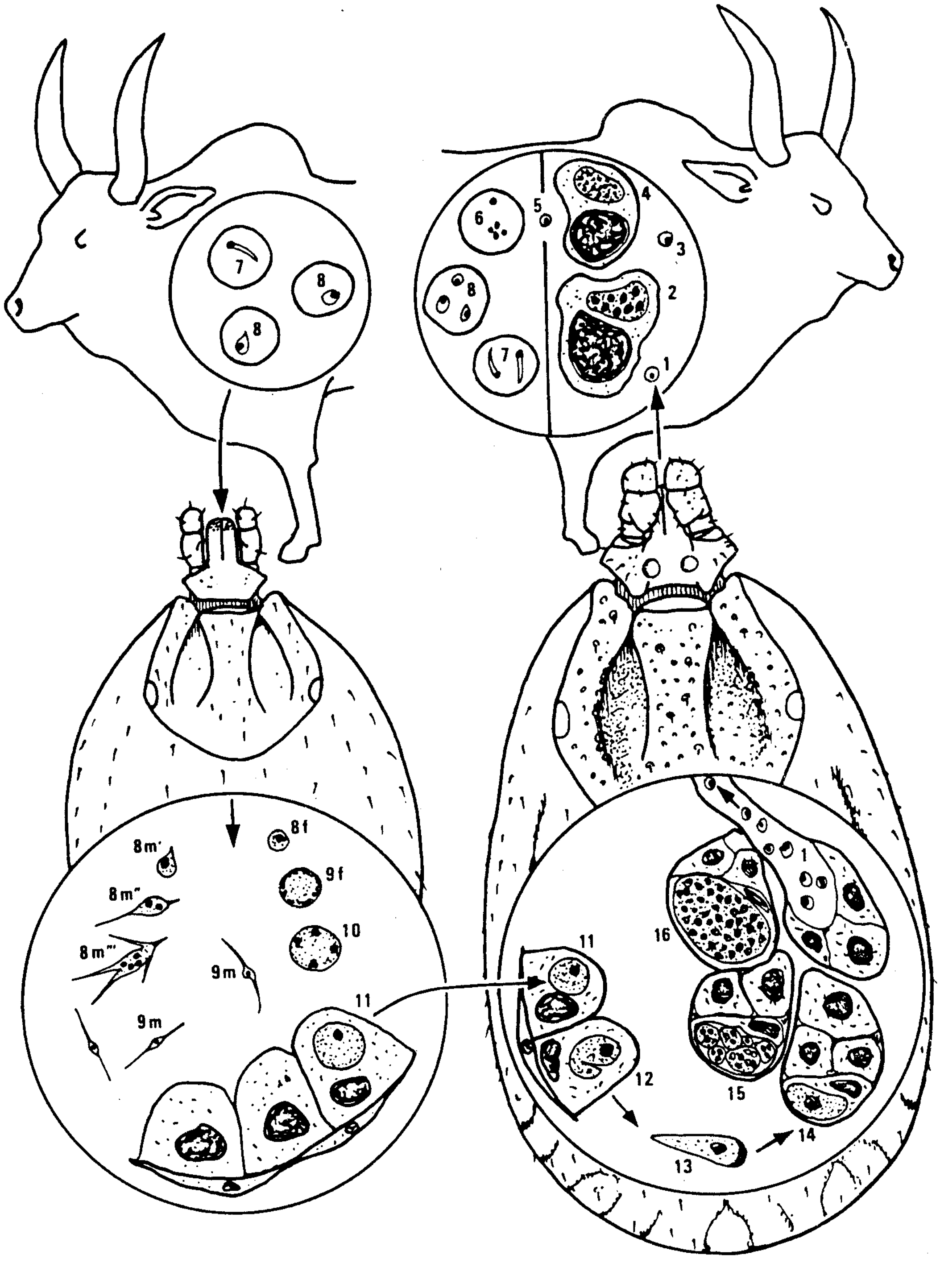


Figure 10. Cycle of *Theileria* in cattle and Rhipicephalus species (Chartier *et al.*, 1989) (refer to key on next page)

In cattle

1: infective metacyclic sporozoite inoculated by ticks

2: macroschizont (agamont) in lymphoblast (Koch's blue body)

3: macromerozoite infecting other lymphoblasts

4: microschizont (gamont) in lymphoblast

5: macromerozoite that infects erythrocytes

6: punctiform erythrocyte trophozoites

7: elongated erythrocyte tropophzoites, bacilliform or comma-shaped

8: stubby erythrocyte trophozoites, circular or piriform, functioning as gametocytes

In *Rhipicephalus* nymph

8f: globular macrogametocyte with central chromatin

8m: piriform microgametocyte

9f: female macrogamete with peripheral chromatin

9m: male filiform microgamete

10: zygote with peripheral chromatin mass

11: zygote in an intestinal epithelial cell

In *Rhipicephalus* adult female

11: zygote in an intestinal epithelial cell development continues at the end of metamorphosis

12: intra cellular zygote in the process of elongation by fission

13: club shaped vermicular ookinete with salivary tropism in the haemocoel

14: oocyst in salivary acinus cell

15: sporoblast development at the beginning of blood meal

16: sporocyst producing metacyclic infective sporozoites 3 days after attachment

Tick-host relations

The adult Hyalomma vectors of Theileria annulata are active during the hot season. They easily adapt to the domestic conditions near cowsheds, such as enclosures, courtyards and village wasteland. In the high-altitude savannas of East and southern Africa, Rhipicephalus appendiculatus is active most of the year. There is an almost permanent risk of Theileria parva infection. Theileria annulata and Th. parva are the only strains that are regularly pathogenic in cattle Th. mutans and Th. orientalis are rarely pathogenic. Th. velifera is apparently nonpathogenic (Tatchell, 1969; Young et al., 1988).

2.3.2.3. Anaplasmosis (Gall sickness)

Anaplasmosis are infectious diseases, virulent, inoculable, and noncontiguous, that affect domestic and wild ungulates. Their causative agent is a Rickettsia of the genus Anaplasma, usually transmitted by infected ticks, but which may also be transmitted mechanically by biting flies (horse flies, Stomoxys). The pathological signs are febrile, subacute or chronic anemia, reduction of bile production and cachexia.

Anaplasma are exclusively erythrocyte parasites; they are located intracellular and are completely surrounded by a parasitophorous vacuolar invagination of the host cell. The infection begins with an initial body that increases in volume to form the elementary body. This later multiplies by doubling or binary fission to give new initial bodies. After several binary fissions, some 4-8 initial bodies form a mass in the vacuole (not distinguishable though an optical microscope). They leave the host cell, often without lesions, and parasitize other erythrocytes (Katherine, 1980; Chartier et al., 1989).

The different anaplasma species cannot be distinguished by their morphology. The criterion used is the marginal or central location of the parasite in the erythrocyte. Anaplasma marginale is pathogenic, while A. centrale is only slightly pathogenic and can be used for premunation.

Anaplasma tick relations

In ticks, *Anaplasma* multiplies in the lumen of the digestive tract. The disease is transmitted from one instars to another. *Anaplasma* tick relations only account for some of the transmission possibilities. The parasite has no cycle in the tick and only multiplies in the intestine (Tatchell, 1969; Young *et al.,* 1988).

Tick-host relation

The periods of activity occur during the relatively long hot, wet seasons of variable duration, depending on the climate. They are not related to the type of vector (*Boophilus, Amblyomma*, or biting insects). Considerations in the infection risks of babesioses in endemic or disease-free regions can be applied in the case of anaplasmosis, since babesioses, theilerioses, and other diseases or inter current physiological disorders, provide favorable conditions for anaplasmosis (Katherine, 1980).

2.3.2.4. Cowdriosis of ruminants (Rickettsiosis, Heart water)

Heart water is an infectious, noncontiguous disease of cattle caused by *Cowdria ruminantum*, which is virulent, inoculable, and can only be transmitted by ticks. Its symptoms are characterized by gastroenteritis associated with exsudative pericarditis, very often followed in acute and percute forms by serious nervous disorders of an encephalitic character (Mekonnen, 1996).

Cowdria- tick relations

Because of the low *Cowdria* parasitaemia rate in the peripheral blood, only a very small number of *Amblyomma* nymphs and even fewer larvae are infected. But the abundance of *Amblyomma* compensates for this low rate. A long-term regional climatic variation influences the distribution of ticks by fluctuations advances and retreats of the *Amblyomma* sometimes over distances of several hundred kilometers. In this situation, young animals may no longer be premunized for many years at a time (Willadsen, 1999).

Tick-host relations

Cowdriosis appears as a seasonal phenomenon linked to the vector cycle. There is a resurgence of cases in endemic countries during the rainy season. The distinctions between stable, unstable, and critical situations for babesioses are valid for cowdriosis. Because of the low percentage of infective adults in spite of their large number the situation is generally unstable, with high risk (Young *et al.,* 1988; Chartier *et al.*, 1989).

2.3.2.5. Distribution of tick born diseases in Ethiopia

Tick-born diseases of cattle such as*, babesioses, theilerioses* (*T. mutans*), *anaplasmosis* and *cowdriosis* are present in Ethiopia but their significance in terms of mortality and production loss and the degree of enzootic stability are not well known. There are no clinical or serological reports of the presence of either bovine tropical *theilerioses* (*T. annulata*) or East Coast fever (*T. parva*). However, the relatively uncontrolled movement of livestock from Sudan, where these diseases and their vectors are found, suggests that there is a considerable risk of the diseases being introduced. *B. bovis T. oriental* and *T. velifera* were reported from western Ethiopia (Mekonnen, 1995).

Infection by *A. marginale* is widespread in the country as its major vector *B. decoloratus*. The impact of this disease on the livestock industry of the nation is negligible. *Babesioses* is mainly a disease of cattle in Ethiopia and is caused by *B. bigemina* (Vector *B. decoloratus*) and *B. bovis* (vector *B. annulatus*). Infection with *B. bigemina* is widespread in the country and *B. bovis* is of recent origin in the livestock disease scenario of the country and has so far only been detected in Gambella, southwest Ethiopia (Radley, 1980).

Table 5. Distribution of tick born disease agents in Ethiopia (Mekonnen, 1998)

TBD agents	Principal vector	Distribution
Anaplasma marginale	*B. decoloratus*	Country wide
Babesia bigemina	*B. decoloratus*	Country wide
Babesia bovis	*B. annulatus*	Southwest Ethiopia (Gambella)
Cowdria ruminantum	*A. variegatum*	Country wide
Theileria mutans	*A. variegatum*	Country wide
Theileria orientalis	A. cohaerens	Southwest Ethiopia
Dermatophilus congolensis	A. variegatum A. cohaerens	Country wide

Cowdriosis (Heart water) caused by *C. ruminantum* is considered to be the most important tick born disease of exotic and crossbred cattle in Ethiopia. Its economic importance is recognized but not well documented. The most important tick vector of Heart water is *A. variegatum* that is widespread in the country. For years, the disease has been known to be present in Ethiopia (Lall, 1981; Mekonnen, 1998).

Theileria mutans has been known for a long time, to occur in Ethiopia. It is certainly as widespread as its vector *A. variegatum.* Eventhough, they are less pathogenic or apathogenic the occurrence of *T. orientalis* and *T. velifera* in cattle in western Ethiopia was confirmed on morphological and serological grounds (Radley, 1980; Mekonnen, 1998).

Dermatophylosis is one of the most serious disease constraints on livestock production in Ethiopia. It is an exsudative dermatitis caused by *D. congolensis.* Whatever the influence of breed and season, it has long been noted that outbreaks are associated with the presence of tick *Amblyomma spp.* (Morel, 1980; Mekonnen, 1998).

2.3.3. Enzootic stability (Premunity)

The natural method of limiting the impact of most tick-born diseases in livestock population is by the establishment of enzootic stability. This occurs naturally when nothing is done to control the disease or its tick vector, resulting in a stable enzootic disease situation with high prevalence of infection in the target population caused by a high transmission rate between vector tick and the vertebrate host. Offspring derived from immune parents are thus infected early in life when they have natural neonatal or calf hood resistance to the disease and perhaps colostral antibodies from the dam. After this the surviving cattle are both immune and are most commonly carriers of the infection. This in turn creates the potential for high infection rates in the tick vectors. The concept of enzootic stability is not applicable on the case of a highly susceptible cattle population and a highly pathogenic disease agent, such as *Theileria parva*, in introduced cattle (Seifert, 1996).

Using vaccines or drugs that help animals to survive primary infection with the disease, and/or using animals that are genetically resistant to disease can assist the creation of enzootic stability. Conversely, this balance is disturbed and may be destroyed by breaking the arthropod vertebrate transmission cycle an act most commonly affected by the application of acaricides (Willadsen and Jongejan, 1999).

Zebu cattle, ticks and tick-born diseases in Ethiopia exist in equilibrium as enzootic stability. This means that animals get infested when young, some mortality occurs in calves and then the animals get naturally immunized against both ticks and tick-born diseases for life. However, they grow slowly and generally show poor performances, furthermore, stress due to disease, poor nutrition or other causes, breaks this equilibrium and outbreaks of tick-born diseases may occur. This is the way cattle have survived in Ethiopia before we knew tick control measures. Farmers still practicing the combination of acaricide application and traditional methods of tick control whenever they consider their animals have too many ticks. In this way they are maintaining the enzootic stability (premunity) (Gebre, 1997).

European cattle are being imported into Ethiopia in order to improve productivity. The majority of the cattle imported are of Friesian type and they are normally chosen from countries where strict tick control regimes or no ticks exist. In this way they are highly susceptible to ticks and tick-born diseases and they are kept alive by intensive application of acaricides as often as every three days, a highly costly procedure (Regassa, *et al.,* 2003).

Such cattle remain susceptible to ticks and tick-born diseases all their lives and if the supply of acaricides is interrupted, very heavy losses will occur. Furthermore, the intensive application of acaricides to these animals kills the vast majority of ticks. However, the few which remain alive do so through the development of alternative metabolic pathways and develop acaricide resistance which forces the farmers to replace acaricides for new ones at an even higher cost (Allen, 1979 and Regassa *et al.,* 2003).

2.3.4. TBD- diagnostic sample preparation and identification

Preparations for identification

Preparation of specimens for identification involves collection and staining. Specimens should be collected before therapeutic or prophylactic treatments since they reduce the number of parasites in the specimens. A treatment against a protist, which is not based on characteristic symptoms or parasite identification, is not only ineffective, but may also hinder the subsequent search for the causative agent. Specimens are collected for thin or thick blood smears, and biopsy smears of lymph nodes, liver, and other organs. Impression smears of organs (liver, kidneys, lungs, heart, cerebral cortex, etc), or crushed preparations of the cerebral cortex are taken from the carcass. The examination of histological sections for parasites may yield useful information (Stringer, 1968).The most common method is the May-Grunwald Giemsa technique that combines fixation and staining. A simpler technique that avoids the May-Grunwald precipitates is fixation in methanol and direct staining in diluted Giemsa.

Serological diagnosis

The serological techniques require specialized training, but serum samples can be taken for detection and identification of antibodies (Uilenberg, 1990; Wikel, 1999).

2.4. Tick and tick born diseases management

Tick and tick born diseases management should look in to the impact of the disease in the livestock farming and agricultural productivity. Impact assessment of tick-born diseases and their control is an increasingly important consideration in the light of ever more scarce resources, and should be incorporated into tick-born disease control programs to ensure their long-term viability. Impact assessment, with reference to tick-born disease control, is a multidisciplinary evaluation of the effect of these diseases on agricultural productivity, and the effect of alternative interventions to relieve them.

The management plans have to find a solution to the following questions:

- How important are tick and tick-born diseases as a constraint to livestock productivity? This requires an evaluation of their effect on parameters such as mortality, morbidity, milk and meat production, traction and other direct and indirect products of livestock production systems.
- Where do tick and tick-born diseases occur, where are they a priority and where are they not? This requires an assessment of the different risks of the effects of tick and tick-born infections to which cattle are exposed. This will vary according to climatic factors and agro-ecological factors, cattle susceptibility factors, economic factors, as well as the relative priority attributed to different geographical regions, socio-economic groups and livestock products.
- Which is the best strategy to control tick and tick-born diseases? This requires an assessment of both epidemiological and socio-economic consequences of alternative disease-control interventions.

- At which level of exotic blood milk production with exotic cattle breeds is it feasible and economically acceptable? This involves the assessment of tick and tick born disease resistance and environmental tolerance of exotic breeds to select those that produce better with less production cost.
- What other constraints need to be addressed in order tick and tick-born disease control to have its optimal impact? This involves assessments of the other factors likely to impede the optimal adoption and improved production (Perry, 1996).

2.4.1. Tick management

Tick populations are typically managed for two reasons: to reduce tick-born disease risk or to reduce tick abundance. Different management approaches are required for each objective. Regardless of which objective is sought when managing ticks, seasonal occurrence, localities, and their associated vegetation characteristics are key factors in management. All of these factors should be considered for either management objective so that problematic areas can be pinpointed and focused upon. Due to their seasonality and low numbers, adult ticks should be the focus when the objective is to reduce tick abundance. By doing this, the next year's reproduction could be reduced.

The wide diversity in tick control practice in Africa and the discrepancies between policies and actual practice in acaricide usage and also the trend towards reduced dipping made tick control strategies in African countries more difficult. Nowadays integrated control strategies are the ultimate options in tick and other parasite control.

Integrated tick control requires combination of many technologies in to specific tick management systems. Individual components include new acaricide formulation and delivery systems, biological control, ecological control, immunological control, genetic control and regulatory control. Computer simulation models based on a qualitative ecological database are extremely useful in devising and monitoring integrated tick management approaches to control ticks which affect livestock. However, several forces are accelerating a global shift to integrated tick management.

These accelerating forces include: reduction in new chemical compounds registered for use in livestock and poultry, universal development of resistance to acaricides, heightened environmental sensitivity to exclusive dependence on acaricide-based control and need for strategies which increases profits for producers while decreasing costs for the consumer (George *et al.,* 2002).

For implementation, a number of major impediments to integrated tick management must be overcome. These problems can best be solved through a vigorous technology transfer program. In addition to face-to-face meeting between farmers, extension agents, and animal health professionals, it can be further encouraged by the publication of articles in magazines and on radio and television broadcasts to the agricultural sector. For several tick species, acaricide control, vegetation management, host management and regulatory control are integrated (Bram *et al.,* 2002).

Moderation in acaricide use is a consequence of new developments in the control of ticks and tick-born diseases in Ethiopia. Factors likely to encourage a reduction in acaricide use include: the availability of vaccines for the control of tick and tick born diseases, an evidence that frequent acaricide treatments are not justified because of the high cost of production and also such treatments can cause loss of immunity to ticks and tick born diseases, planning of treatments based on a sound knowledge of tick ecology and financial burden of acaricides to farmers and government (Kunz and Kemp, 1994; Mekonnen *et al*., 2001)

Starting in the recent past, new methods of tackling the problem of tick control are being applied. These include: new methods of applying acaricides such as ear-tag and bands, intra-ruminal and other slow release devices (which are highly expensive methods for countries like Ethiopia), the use of attractants, repellent, management methods like pasture spelling and strategic dipping and finally exploitation of genetic resistance of the host to tick infestation have been considered of all these methods, the one which so far had most impact on the control of ticks is that use of natural resistance of the host animal to the tick. The Caribbean tick control program has adopted an innovative approach to tick eradication based on direct animal owner and community participation. Government teams are mandated to ensure that farmers comply with the treatment schedule, supported by training and legislation. This is reinforced by intensive public information and sensitization campaigns directed to livestock owners and the general public (Pegram, 2000).

Treatment frequency

The treatment schedule should be established according to the tick life cycle, season, and transmission mode, in line with the campaign objectives. The treatment pattern is not necessarily the same throughout the year, due to variations in the seasonal dynamics or phenology of each species. A study of tick dynamics enables the identification of the stages that should be controlled to break the life cycle most effectively. Larvae or nymphs should be systematically destroyed to avoid parasitism at the adult stage. Moreover, immature stages are more sensitive to acaricides. The main danger of adult ticks is not damage to the host, but that they can produce progeny or completing the cycle (Bekele, 2002).

The final objective is to control progeny, rather than destruction of the ticks. An obvious way to achieve this result is to destroy the adults, but often it is enough to prevent females from oviposition or eggs from hatching. These general principles should be developed further while planning a campaign against particular cattle parasites (Kemp, 1994; Bekele, 2002).

2.4.2. Tick born diseases management

Tick born diseases constitute an important constraint on the livestock production in Ethiopia, in particular for the production of exotic cattle in southwestern regions of the country. Tick born protozoan diseases (babesioses and theilerioses) and ehrlichial diseases (cowdriosis and anaplasmosis) are main health and management problems, which prevent upgrading of cattle in many regions of Ethiopia. Integrated control strategies have been advocated, based on host resistance to ticks and the diseases they transmit, strategic tick control taking into account the seasonal dynamics of tick infestations, availability of vaccines against tick born diseases, and cost benefit analysis of acaricide and antibiotics used is essential for tick born diseases management. In areas where acaricide treatment are the most appropriate tick control method and where enzootic stability to tick born diseases is present, ways need to be found to use those acaricides, which do not destroy the enzootic stability.

A prerequisite for the development and maintenance of enzootic stability is that almost all animals are challenged when young. Therefore, treatment of cattle with acaricide should not reduce tick born disease challenge below the level that is required to maintain an enzootically stable situation (Perry, 1996).

Control of tick-born diseases in Ethiopia still depends mainly on intensive tick control with acaricides. However, these chemicals are toxic and costly and resistance of ticks to acaricides constitutes a major threat to the livestock production, particularly in southwestern regions. Control of any particular tick-born disease cannot be considered in isolation from other tick born or tick-associated diseases, since in general, several tick-transmitted disease agents which are present in the same geographical region are likely to occur simultaneously. Therefore, any effective program will need to target several parasite species, including tick, simultaneously. Epidemiological studies and economic assessment of the impact of ticks and tick-born diseases on subsistence or higher production livestock economies of the countries were also required (Mekonnen, 1998; Pegram, 2000).

3. Own investigation

The study was conducted to investigate the distribution of ticks in overall the Jimma zone and also to determine the seasonal variation of tick species in five localities around Jimma town and to develop a strategy for the control of tick and tick born diseases of the zone. The study has considered the traditional control practice, financial status of farmers and the veterinary service rendered by the government in the region.

Relevant data on the seasonal dynamics of the major ticks species in a defined geographical area is a prerequisite and useful to design control strategy. That is without understanding of the seasonal phenology of ticks, control programme may not be successful. Therefore, the present investigation was initiated with the objectives to study the seasonal distribution of ticks in Jimma zone, in order to generate data that may be used to design control strategy by professionals and also to examine variation of infestation among the animals of different breeds. Finally, to come up with feasible and farmer's affordable tick control management plans to protect cattle from tick and tick born diseases in the region.

3.1. Jimma Zone

3.1.1. Geographical description

Jimma is situated in southwestern Ethiopia, lying between latitude 6° and 9° north and longitude 34° and 38° east. The altitude ranges from 700m to 2300m above sea level. It is one of the twelve zones in Oromiya. The relief of the zone generally reveals a decreasing altitude from west to east and northwards. In general, the physical features of Jimma zone depict a dissected and undulating plane.

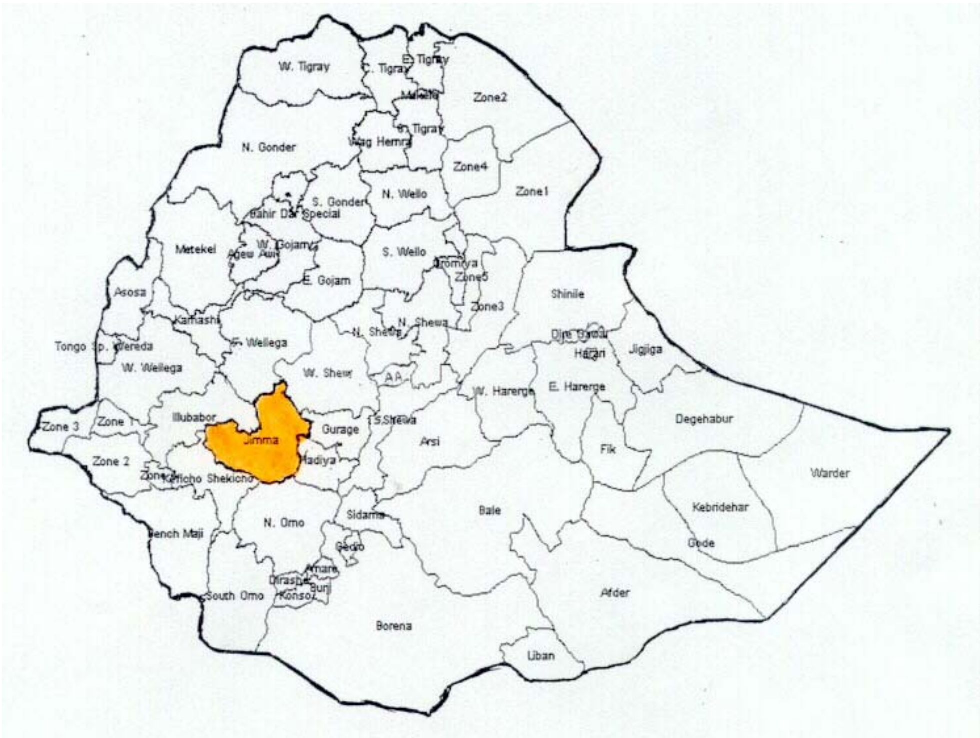


Figure 11. Administrative zones of Ethiopia

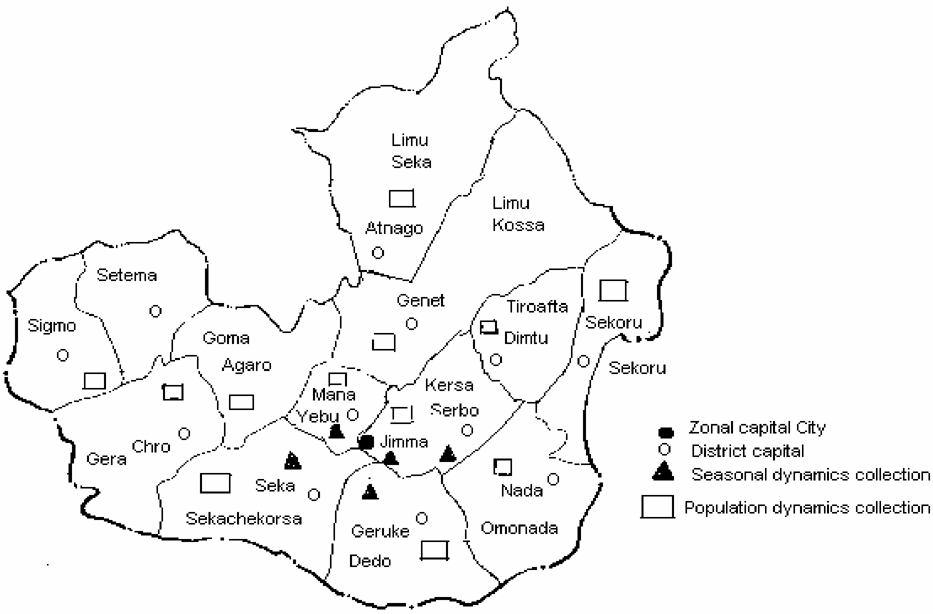


Figure 12. Jimma zone administrations

3.1.2. Climate

Climatically, Jimma zone is characterized by tropical climate of heavy rainfall, warm temperature and long wet period. The central and southwestern highlands experience temperate (Weinadega) and cool temperate (Dega) climate. The climate varies from wet and humid during heavy rains between May and September to hot and semi-arid condition between November and April. Rainfall received during winter, which lasts from late May to early September, constitutes about 70 % of the total annual rainfall reaching the area. February, March and April are months of autumn rain. Rainfall during the remaining months tends to be minimized. Generally average annual rainfall in the zone ranges between 1200-2000 mms. Maximum temperature in Jimma zone is on the average 23 ^{o}C to 30 ^{o}C. On the other hand minimum temperature is between 7 ^{o}C and 13 ^{o}C during the months of October to December (CSA, 2002).

3.1.3. Land use, soil, forest and wild life

Jimma zone has an area of 18412.54 square kilometers with a population density of 138.5 per square kilometer. According to the Ethiopian central statistics authority report of 2003 the larger percentage of land in Jimma zone is devoted to temporary crops. The rest is permanent cropped land, grazing, woodland, fallow land and unproductive land listed in order of coverage. It has 443728 agricultural households in all holders, a total of 2.3 million populations with an average of 5.2 members per household.

The distribution of agricultural households by type of farming system shows 80.9 % crop livestock farming, 18.7 % crop only and 0.4 % livestock only. Cropped land in the area is about 470714 hectare contrasted with the population residing in the same area; we obtain an agricultural density of about 3 persons per hectare for the zone. Annual crops cover about 68.3 % of the cultivated land. Maize and sorghum are top on the list of annual crops planted, followed by teff. The remaining 17 % of zonal land consists of perennial crops- mainly coffee, enset and chat (CACC, 2003).

Orthic acrisols are the dominant type of soil in Jimma zone and are the type found in the southern and northeastern parts of the zone. Dystric nitosol are common in the western and northwestern section vertisols are the least dominant type and are mainly located in the central and eastern parts and northwestern periphery of the zone. Systematic regional investigation of mineral occurrences has been very minimal to date. There is a lack of sufficient information and data regarding this resource and the few available, if any, are incomplete (CPA, 1994).

The zone is in a relatively better status with regard to forest cover. Slightly more than one fifth of the land or about 21.8 % of the area is covered with forest resources. The type is predominantly the natural type of dense mixed and disturbed high forest. They are characterized by a great variety of tall trees, with widely spreading crowns, such as, Kerero (*Aningozia altissima*), Tikurinchet (*Prunus africanus*), Wanza (*Cordia africana*) and Bisanna (*Croton macrostachys*)**.** Jimma zone has also a variety of wild life. The most common species as buffalo, leopard, lion, greater kudzu, civet, warthog, bush buck, reed buck, bush pig, porcupine and spotted hyena. The rivers abound with plenty of crocodiles and hippopotamus. Monkeys and apes are commonly seen in herds in the area. Although there are varied species of wild lives there are no national parks, game reserves or bird sanctuaries in Jimma zone (CSA, 2003).

Table 6. Distribution of area and holders by type of land use for private holdings in Jimma zone (CACC, 2003)

	Annual crop	Permanent crop	Grazing land	Fallow land	Wood land	Other land	Total
Area in hectares	321332	66614	42247	27313	3669	9539	470714
Percentage	68.3	14.2	9.0	5.8	0.8	2.0	9.1
Average area / holder	0.73	0.16	0.28	0.18	0.07	0.02	1.03
Average parcel/ holder	2	2	1	1	1	1	3
Average area/ parcel (ha)	0.31	0.11	0.23	0.15	0.06	0.02	0.35

Table 7. Distribution of cropland area in hectares by crop categories Jimma zone (CACC, 2003)

Temporary (Annual) crops			Permanent crops		
Crops	Amount (ha)	Percentage	Crops	Amount (ha)	Percentage
Cereals	273719	85.2	Coffee	43453	65.2
Pulses	24472	7.6	Enset	12775	19.2
Oilseeds	10753	3.4	Chat	7195	10.8
Root crops	7402	2.3	Fruit	2200	3.3
Vegetables	4348	1.4	Sugar cane	916	1.4
Others	638	0.1	Others	75	0.11
Total	321332	100	Total	66614	100
All cropland	387946				

3.1.4. Livestock

Livestock holdings include cattle sheep, goat, horses, mules and donkeys. Poultry are also kept. Animals are usually housed together at night, the more valuable livestock such as calves, lactating cows and breeding jacks often being kept in the family dwelling. Oxen are the mainstay of small holder's production, being employed as draft animal for land preparation and threshing of crops. Cattle found in Jimma zone and throughout much of southwestern regions is mainly Abyssinian short horn zebu. Animals have a pronounced hump with various coat colors including gray, reddish, white and black, occurring either in solid, stripped or mixed patterns.

Although the present census reports on agricultural production shows the structure of agriculture in Jimma zone is made of 3/4 crop-livestock production and 1/4 for crop production only and insignificant number of livestock production only (CACC, 2003).

Table 8. Number of livestock and poultry in Jimma zone by sex in all holdings 2001/2002 in thousands (CACC, 2003)

Animals	Holdings			Sex		
	Rural	Urban	Total	Male	Female	Total
Cattle	1690	28	1718	801	917	1718
Sheep	463	3	466	108	358	466
Goat	191	4	195	53	142	195
Horse	74	1	75	29	46	75
Asses	40	1	41	25	16	41
Mule	30	0.1	30.1	9	21.1	30.1
Poultry	1766	43	1809			1809
Beehives	447	14	461			461

3.1.5. Human population

Projections based on the census report by the central statistics authority for 2002 indicate that the population of Jimma zone is about 2.5 million (1.27 million male and 1.28 million female) in July 2002 with annual growth rate of 2.9 %. Among the total population, 80 % is rural and 20 % urban dwellers (CSA, 2002).

3.2. Materials and methods

3.2.1. Materials

3.2.1.1. Cattle breeds

For distribution study ticks were collected either from the veterinary clinics or neighboring farms where cattle are available. A representative sample of ticks both male and female found in different body zone of cattle was taken at each locality from different herds.

For seasonal dynamics study the collections have been done from 50 cattle 10-36 months old at the beginning of the study. 35 were indigenous zebu and fifteen zebu crosses with Holstein Friesian having different blood level, representing different management systems, sex and weight groups. These cattle have been selected from herds of the study area based on an initial tick count. Ten cattle from each locality with high infestation in the initial tick count were selected and ear tagged for permanent identification.

Monthly whole body collections of tick have been accompanied by general check up of health status. The collection was repeated for twenty-four consecutive months at monthly interval on the selected cattle from September 1998 to August 2000. In the course of the two years similar cattle have replaced seven cattle because two have died, two had been slaughtered and three had been sold.

Figure 13. Cattle type in the region (top photo dry season bottom rainy season)

Figure 14. Exotic breed infested with ticks (Brain, R. (1997)

3.2.1.2. Acaricide used

The selected cattle for seasonal dynamics study were hand sprayed with Norotraz® 12.5 % (from Norbrook Laboratory, Newry, North Ireland) which is an emulsifiable concentrate containing amitraz. Amitraz is used for the control of ticks, midges and lice as a 0.25 % dip or spray. In contrast to most other cyclic amidins, the compound has a good residual effect and fast action 90 % of the ticks drop off the animal within 8 hours post application. Because of its diffusion effect within the coats of the animals, the compound also becomes effective on parts of the body surface, which have not been reached by the spray application.

Amitraz has very low toxicity for animals. After oral application, the DL_{50} for rats is 1900 mg/kg body weight and 4100 mg/kg body weight after dermal application. Horses cannot be treated with amitraz. Residues are found in the milk only within 24 hours post application and the MRL of 0.01 ppm is not reached. The compound may be used within dairy production without a withdrawal time. The withdrawal time for beef is 24 hours. If Amitraz is used for surface treatment, its high toxicity for fish has to be taken into account. The contamination of water must, therefore be prevented.

The aim of spraying is to standardize tick burdens at the trial initiation and then left in their respective herd for a month prior to the commencement of sampling. No acaricide treatment was administered then after during the rest of the study period.

3.2.1.3. Variations of the study area

The distribution survey was conducted in twelve administrative divisions of the zone from more than 22 localities. A total of 19672 ticks were collected from 963 cattle of the rural and urban farmers. The population dynamics study was done during the first year 1998/99, most of the collections were done from cattle coming to the veterinary clinic of the region.

The seasonal variation study was carried out in five localities of Jimma zone (Jiren, Bore, Blida, Merewa and JUCA dairy farm). These areas were selected on the basis of location, climate and altitude and cattle population. The sites were a representative of the major climatic types of the zone namely areas with rain most of the year and located at different altitudes. These localities were all year round road accessible.

3.2.2. Methods

3.2.2.1. Collection and preservation of samples

Tick collection was done during its parasitic phase from the animal only. Sample collection was done in accordance with the method developed by Londt *et al.,* (1979). Collected samples have been placed in sample vials containing 6 % formalin with 3 % glycerin. The samples were labeled immediately after whole body collection of each animal completed. The label contains the locality, owner's name, animal identification code, date and month of collection.

The samples then were counted and identified in the laboratory using hand lens and stereomicroscope on the same day or on the next days. Identification was done based on morphological and structural differences of the species and different instars. The grouping to their genus and species was made according to the methods developed by Hoogstraal (1956) and Keirans *et al.,* (1999).

Of seasonal dynamics studies collection where only the two species *B. decoloratus* and *A. cohaerens* were in question, other species collections were counted and discarded after the identification.

3.2.2.2. Classification of ticks by genera

Table 9. Keys for classification the genera hard ticks (Ixodidae) Hoogstraal (1956)

	The genera of ticks						
Structures	Ixodes	Hyalomma	Amblyomma	Dermacentor	Haemaphysalis	Rhipicephalus	Boophilus
Gnathosoma	long			short			
Basis capituli	rectangular dorsally					hexagonal dorsally	
Eyes	absent	present			absent	present	
Anal grooves	anterior	posterior					
Coxae I	not forked	bifed	with two spurs	bifed	not forked	with two spurs	bifed
Festoons	absent	pre/abs	present				absent
Scutum color	inornate or ornate		ornate		inornate		
Males ventral shields	cover all the surface	three pairs of shield	absent			two pairs of shields	

3.2.2.3. Identification of tick species B. decoloratus and A. cohaerens

Morphological specificity of *Boophilus decoloratus*

Male: - Very small, straw yellow, translucent, readily distinguishable from *B. annualtus* by a median, posterior caudal protuberance (fig. 15-3). Body covered with long white hairs. Basis capituli about 2 times as broad as long, posterior margin short, straight, apex rounded; lateral margins broadly rounded (fig. 15-1). Palpi short and broad, hairs similar to those on basis capituli (fig. 15-1). Hypostome spatulate, small; moderately well developed corona. Scutum completely covering the body, color varies from yellow to pale brown (fig. 15-3), frequently translucent. Cervical grooves hallow punctations shallow with fairly uniform distribution. Eyes small, flat and yellow.

Legs are of moderate length, with the individual segments very thick. Coxa I is very strong have long anterior process and broad tapering internal spurs (fig. 15-7). Coxae II and III broadly rounded external spurs, external spurs on coax IV much reduced and more frequently absent. Tarsus I dilated on both upper and lower surfaces as far as the level of Haller's organ. Metatarsus I wider distally than proximally, but not unduly thickened. Claws longer than pulvilli. Ventral plates are well supplied with long white hairs. Adanal plates originate on anterior level of anus, and produced medially and backwards as a long narrow internal spur; accessory adanal drawn out in to a sharp long spur; few moderate punctuations (fig. 15-4). Genital opening is on a level with coax II.

Female. Unfed specimens small, elongate oval in outline. Body hairs of opisthosoma as long as those on the scutum. Lightly sclerotised and unfed females are frequently translucent. Short median groove and two longer lateral grooves on opisthosoma.

Capitulum: - basis capitulia about two and half times as broad as long. cornua lacking; lateral margins divergent for about three-quarters of the length, terminate in point on each side, (fig. 15-8). Ventrally basis capituli broadly rounded. Surface divided in to proximal and distal parts by a shallow transverse groove.

Surface in front of this groove is steep to base of hypostome (fig. 15-9). Hypostome is longer in females, spatulate with 10-11 files behind an apical corona. Scutum is generally longer than greatest width. Scutal margin, more commonly in front of eyes, curves slightly outwards, behind eyes margins almost rectilinear, terminating in a narrowly rounded posterior margin (fig. 15-10). Hairs of moderate length are most abundant anteriorly between the cervical grooves and in region of eyes. Legs are long but not as stout as in male. Coxa I triangular, with two well-defined spurs, both broadly rounded apically, separated by a narrow, deep inverted V-shaped cleft (fig, 15-14); coax II with broadly a rounded external spurs, coxae III and IV with slight marginal saliences externally, coxae II and III distinctly longer than broad; all bearing long fine white hairs. Genital opening is on level with coax II; genital groove sub-parallel to just beyond coax IV then more strongly divergent, do not reach postero-lateral border.

Nymph: - Well-fed specimens being widest front, constricted at about the level of coxa IV and tapering to a broadly rounded posterior edge. Capituli rather variable in size, posterior margin only slightly convex; cornua lacking. Hypostome is short and broad. Scutum shape is widest at about mid-length, postero-lateral margins slightly concave, broadly rounded behind (fig. 15-16). Cervical grooves shallow, divergent posteriorly. Surface finely punctuated and hairs distributed as in (fig. 15-15). Eyes oval, small, faint.

Larva: - Broad oval in shape, Capituli dorsal ridge straight or slightly undulate, lateral margins sharply convex and protuberant. No cornua. Ventrally basis capituli broadly rounded. Hypostome is short with five or six files. Scutum is broader than long, greatest breadth at about mid-length. Surface finely punctuated and bearing hairs. Legs are of moderate length. Coxa I with short broad internal spurs; spurs absent on coxae II and III.

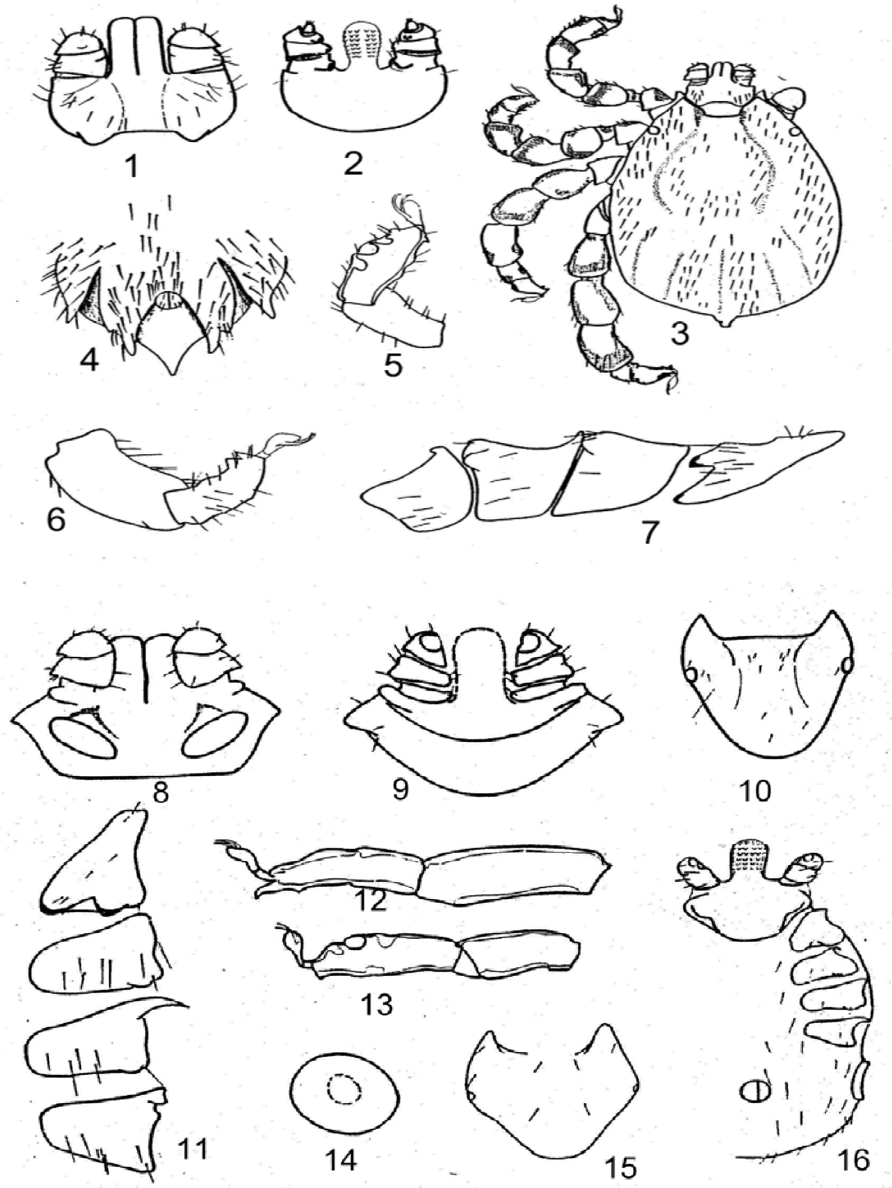


Figure 15. Body parts of *Boophilus decoloratus* (Hoogstraal,1956)

1-7 male 8-14 female 15-16 Nymph

Male 1: capitulum dorsal 2: capitulum ventral 3: dorsal view of tick

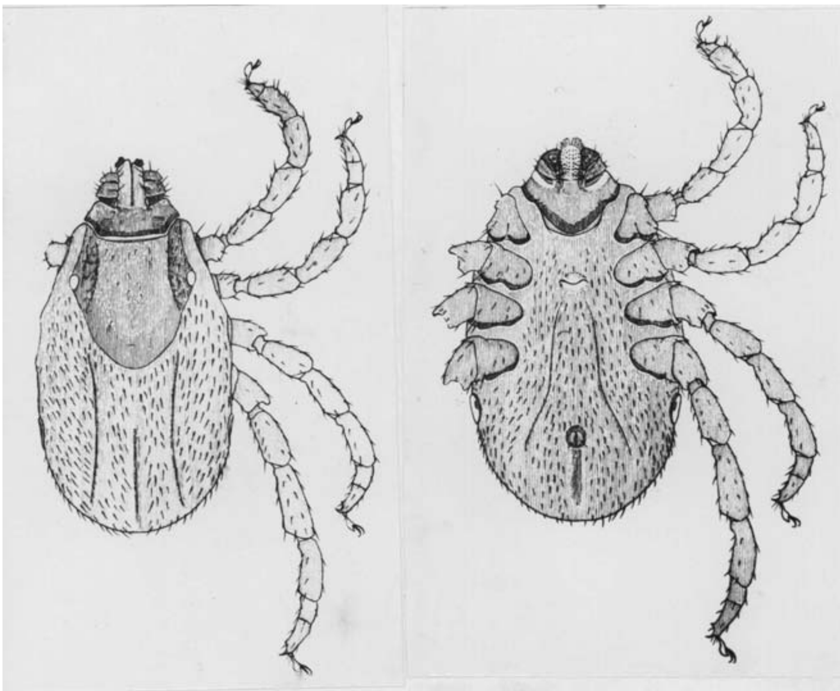
4: posterior part of body to show anal plate 5: tarsus and metatarsus I

6: tarsus and metatarsus IV 7: coxae I-IV

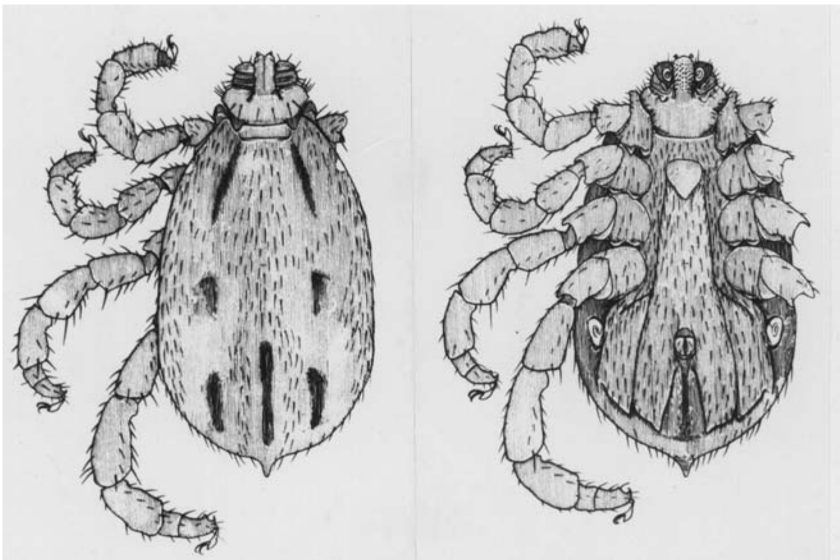
Female 8: capitulum dorsal 9: capitulum ventral 10: scutum 11: coxae I-IV

12: tarsus and metatarsus IV 13: tarsus and metatarsus I 14: spiracular plate

Nymph 15: scutum 16. ventral view



FD FV



MD MV

Figure 16. *Boophilus decoloratus*- Adult male and female (Hoogstraal, 1956)

MD: male dorsal MV: male ventral

FD: female dorsal FV. female ventral

Morphological specificity of *Amblyomma cohaerens*

Male: (fig. 17 and 18) A medium-sized tick; scutum with characteristic ornamentation, consisting of dark-brown or blackish spots and stripes on pale ground; falciform present or absent, postero- median stripe rarely reaching the falciform stripe; postero accessory stripes short, broad and triangular, closely adjacent to the third lateral spots with which they are often fused at base; cervical spots large; cervical stripes long, their posterior ends incurved and fused with the lateral horns of the falicform stripes when this present; lateral spots conjoined to form a broad, bowed. Lateral stripe, the ends of which are fused with the dark marginal coloration; festoons partly coloured; punctuations fine; eyes pale, slightly convex.

Description: Body contour broad oval and little narrower in front than behind. Scutum: smooth, convex; with ornamentation consisting of dark-brown or blackish spots and stripes on a pale ground. falciform stripe present or absent; postero-median stripe rather narrow; anterior extremity very slightly knobbed it at all; rarely fused with the falciform stripe; postero-accessory strips short, broad, triangular, closely adjacent to the third lateral spots with which they are more or less fused at the base; lateral spots conjoined to form a broad, bowed, lateral band, the ends of which are fused with the marginal coloration; cervical spots very large; cervical stripes apparently very long and incurved at their posterior extremities; this appearance is due to the fact that the antero-accessory stripes are fused and end on to the cervical stripes; external and median festoons dark-coloured, 2nd, 3rd and 5th festoons pale, 4th festoon pale in posterior half; cervical groove in the form of elongated, comma-shaped pits; marginal groove continuous, very shallow in the part anterior to the middle; eyes of medium size, pale and slightly convex.

Capitulum: basis sub trapezoidal, postero-lateral angles non-salient; palps long, sides almost parallel, article 2; contracted at proximal end, two and a half times as long as article 3; hypostome long and spatulate.

Legs: Stout, dark maroon-brown with pale-yellow annulations at the distal extremities of the larger articles; coax I with two unequal spurs, the external spur moderately long and pointed, the internal spur short and blunt; a broad, curved, salient ridge on each of coxae II and III, a short, blunt spur, slightly longer than broad on coax IV; tarsi small, attenuated in talus.

Female (fig. 17 and 18): A medium -size tick; scutum triangular, smooth; median field pale- colored; lateral field mostly dark-colored; punctations very fine; eyes moderately large, pale, slightly convex. Body contours oval, slightly narrower in front than, dorsum dark-green, with scattered coarse punctations on posterior half; marginal groove well-define, continuous.

Scutum convex, smooth: triangular, antero-lateral margins convex, scapular angles obtusely pointed, postero-lateral margins almost straight, slightly sinuous; posterior angle moderately narrow; ornate, median field pale-coloured, excepting the part between the cervical grooves; lateral fields dark-colored with or without a small pale spot in the posterior part; cervical grooves short and deep, continued towards the posterior border by very shallow, ill-defined depressions; punctations very fine, coarse but still small in the scapular angles; eyes moderately large, almost circular, pale, slightly convex. Capitulum porose areas large, oval, divergent, interval about equal to diameter. Legs stout, maroon-brown with pale annulations: coxae as in the male spur on coxa I shorter; tarsi attenuated in talus.

Table 10. Identification of *Amblyomma cohaerens* and *Boophilus decoloratus*

	Amblyomma cohaerens		*Boophilus decoloratus*	
Stractures	Adult	Larvae	Adult	Larvae
Scutum color	Ornate	No Scutum	Inornate	No Scutum
Gnathosoma	Long	Long	Short	Short
Basis Capituli	Rectangular	Rectangular	Hexagonal	Hexagonal
Festoons	Present	Present	Absent	Absent
No of Legs	Eight	Six	Eight	Six

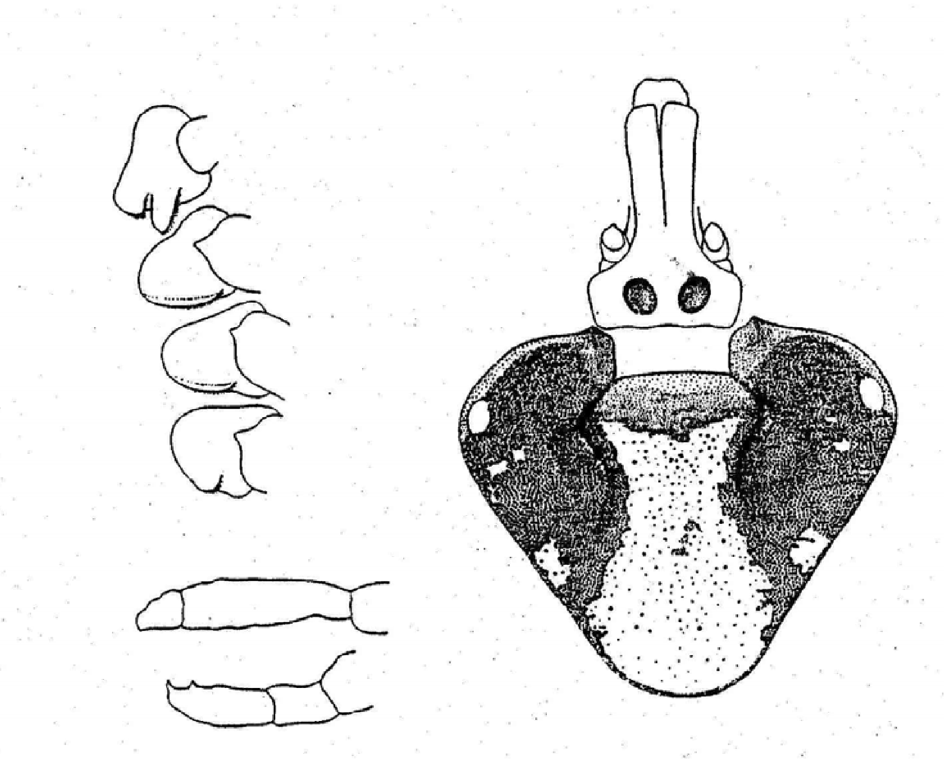


Figure 17. Amblyomma cohaerens Adult female: (Hoogstraal, 1956) scutum, capitulum (palp incomplete) coxae I-IV and Tarsi I-II

Figure 18. *Amblyomma cohaerens* adult male and female (Photo James L. Occi on Internet)

3.2.2.4. Recording

The variables recorded include collection date, animal identification code, sex and breed on one side and the amount by tick by species; instars and sex were recorded in the other side. In addition to sampling, farmers were interviewed about the measures they usually practice to treat and prevent tick infestation in their herd. Along these, ecology metrological data and environment of the region was taken in to consideration. Collection intervals varied from twenty seven to thirty three days. The following parameters were considered during study the seasonal dynamics of ticks:

- Environmental condition of the localities that induce hatching and development
- Health status and inherent conditions of cattle that maintain or reduce tick population

3.2.3. Analysis

The association of the tick count with the meteorological data and the trend of development have been statistically analyzed. The statistical analysis was done using correlation between the tick count, temperature and relative humidity and also the association between the larval, nymph and adult stages of the tick. The monthly variations of tick count by instars have been analyzed by analysis of variance (ANOVA). The relationships between the minimum temperature, relative humidity and maximum temperature with the number of ticks and their instars have been analyzed by correlation of variables.

The dependent variables of interest were larvae plus nymph, adult and total *Boophilus decoloratus* and *Amblyomma cohaerens* population (count). Data were analyzed using the General Linear Model (GLM) procedures of SAS (1996) by fitting a fixed effect model with the effects of year, site (locality) and month. The Tukey's studentized range test was used to separate means with significant variation. Correlations between the dependent variables and relative humidity, minimum and maximum temperature were computed using PROC CORR of SAS (SAS, 1996). Least squares means obtained from the analysis of the model described were used to prepare graphs to illustrate the relationships between the dependent variables (larvae plus nymph, adult and total populations) with month.

4. Results

4.1. Results of the population dynamics

The population dynamics studies gave details of population levels of the major tick species in the zone. The cattle herds were composed of different breeds and age group and the proportion of exotic and indigenous was 70 % Zebu to 30 % Zebu cross with Friesian. On the cattle's eight species four genera of ticks were found: B. decoloratus, A. cohaerens, A. variegatum, R. evertsi evertsi, R. praetextatus, R. bergeoni, R. lunulatus and H. aciculifer. B. decoloratus and A. cohaerens were the most abundant ticks followed by A. variegatum, R. evertsi evertsi, and R. praetextatus. Other genera and species were found only in small numbers (table 11). In different studies of the region, there were variation of tick species manifested, reduction of numbers and repetition of identified species with climatic and altitude changes.

Prevalent tick species in sites with rainfall most of the year were: B. decoloratus, A. cohaerens, A. variegatum, and R.evertsi evertsi. A peak of activity for most species was detected at the beginning of the heavy rains (May, June and July). Owing to favorable climatic conditions, these tick species are present on cattle all year round in moderate number. Due to the significant differences in rainfall and relative humidity during the study months, there was meaningful change observed in tick number. Tick numbers during the dry season are low with a marked increase coinciding with the start of the rains and relatively high tick burdens throughout the rainy season.

Table 11. Tick species collected during the study period

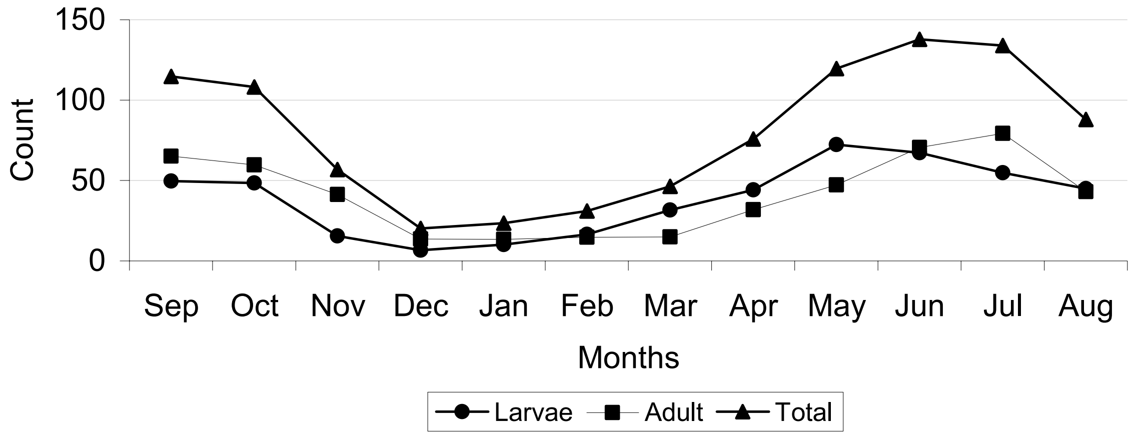
Tick species	Adult	Larva+ Nymph	Total
B. decoloratus	6860	6397	13257
A. cohaerens	2393	2381	4774
A. variegatum	746	562	1308
R. evertsi	194	34	228
R. praetextatus	47	31	78
R. bergeoni	10	6	16
R. lunulatus	5	2	7
H. aciculifer	3	1	4
Total	10258	9414	19672

4.2. Results of the seasonal dynamics

Results of overall means, least squares means (and S.E), CV. (%) and F-test of effects of year and site for larva+ nymph, adult and total *Amblyomma cohaerens* and *Boophilus decoloratus* are summarized in table 12 and 13. There were not significant differences in the infestation (total tick count) between the years. However, significant differences were observed in total tick count between months and the sites. There was considerable variation in tick count between JCA farm and other localities. This suggests that JCA farm cattle were more susceptible to tick infestation than the others.

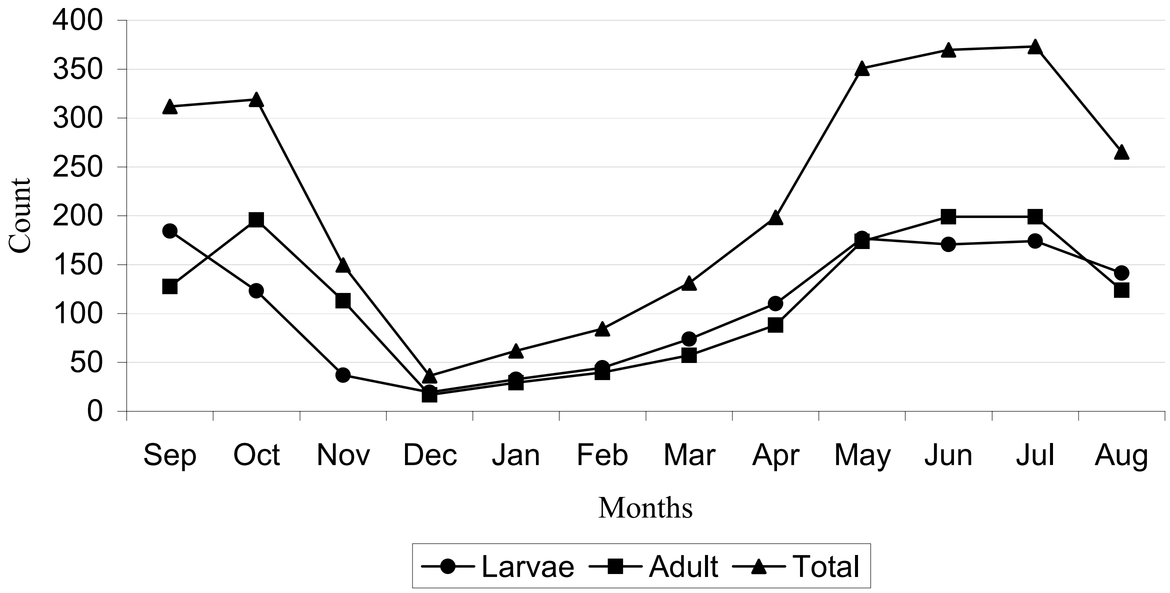
The result on the effect of environment on tick population indicate that both *Amblyomma cohaerens* and *Boophilus decoloratus* are highly dependent on moist microenvironments because of its great susceptibility to percentage losses of total body water, and drop in hemolymph volume at low humidity. This study illustrates that both *Amblyomma cohaerens* and *Boophilus decoloratus* perish rapidly or enter in diapause's syndromes when the humid protection is disrupted. Seasonal activity began in March following the short rainy season when adults exhibited host-seeking behavior on the ground. Ticks began to come up to top of vegetation in April and early May, and a peak in the percentage of ascending tick was reached in late May, June and July**.** The percentage ascending remained constant until late July when ticks began go down to the soil in association with higher humidity and lower temperatures (behavioral diapauses).

Both *Amblyomma cohaerens* and *Boophilus decoloratus* had two peaks of activity, in September and October (moderate) and in May, June and July (maximum). No significant increase in tick population was observed during the short rains. There was, however, a greater buildup coincidence with the main rainy season. There was a direct relationship between population and minimum temperatures, whereas maximum temperature seemed to have no such relationship. Patterns of seasonal activity in Jimma zone for *Amblyomma cohaerens* and *Boophilus decoloratus* on cattle shown on Figure 19 and 20.



P= 0.01

Figure 19. Seasonal variation of the population of total, adult and larvae of *Amblyomma cohaerens*



P= 0.01

Figure 20. Seasonal variations of the population of total, adult and larvae of *Boophilus decoloratus*

Table 12. Overall means, Least squares means (and S.E.), CV. (%) and F-test of effects of year and site for larva plus nymph, adult and total Amblyomma cohaerens

Effect and level	Larva + Nymph	Adult	Total
Overall	38.5	41.2	79.7
C.V.	26.8	29.3	24.2
Year	Ns	Ns	Ns
1998/99	37.3	42.5	79.8
1999/2000	39.7	39.9	79.6
Site	**	**	**
Blida	28.0b	31.5 b	59.6 b
Bore	33.8 b	35.8 b	69.5 b
JCA	69.8 a	74.5 a	144.3 a
Jiren	28.3 b	27.6 b	55.9 b
Merewa	32.5 b	36.5 b	69.0 b

** P= 0.01, Ns = Not significant a is different from b

Table 13. Overall means, Least squares means (and S.E.), CV. (%) and F-test of effects of year and site for larva plus nymph, adult and total Boophilus decoloratus

Effect and level	Larva + Nymph	Adult	Total
Overall	107	114	221
C.V.	29	31.5	24
Year	Ns	Ns	Ns
1998/99	108	113	221
1999/2000	106.6	114	221
Site	**	**	**
Blida	82.1b	80.2 b	162.3b
Bore	89.4 b	93.9 b	183.3 b
JCA	203.8 a	222.2 a	426 a
Jiren	77.8 b	82.2 b	160b
Merewa	83.5 b	89.8 b	173.3 b

** P= 0.01, Ns = Not significant a is different from b

4.3. Climatic effect on infestation

Regular tick collection under quasi-natural conditions in Jimma indicated that the phenology of *Amblyomma cohaerens* and *Boophilus decoloratus* was a result of an intricate interplay between the environmental condition and the tick's diapause's behaviors. There were substantial variations in the total tick count and developmental stages between months as indicated the figure 19 and 20. Table 14 and 15 shows the correlation coefficient between larva plus nymph, adult and total *Amblyomma cohaerens* and total *Boophilus decoloratus* and minimum temperature, maximum temperature and relative humidity. All correlations are significantly different from zero ($P < 0.01$). Tick count and maximum temperature were negatively correlated. Tick count was positively correlated with minimum temperature and relative humidity.

The growth and multiplication of all instars of *Amblyomma cohaerens* and *Boophilus decoloratus* were correlated with mean air temperature. The habitat most favorable for it was also most moderate in terms of temperature and relative humidity. The earliest significant activity of *Amblyomma cohaerens* and *Boophilus decoloratus* begins in May when average ambient temperatures are 19-21 ^{o}C. Of course, soil surface temperatures may rise significantly above this. Peak populations occur in May, June and July and short decline in August second peak again in September and October and decline further until almost non-observed in late December and January. This phenomenon was also observed during other years.

Direct observation on daily activity *Amblyomma cohaerens* and *Boophilus decoloratus* in the peak months of the year revealed a diurnal host seeking rhythm pattern. The cattle pick up and the direct observations of active ticks in an open site showed almost identical results with two marked peaks, one in the morning and the other in the late afternoon. It also appears that the location of these peaks and the magnitude varies according to seasons. During the night cooler month of October and November the morning peaks are delayed to late morning and late afternoon, while during the warmer month of April and May, the morning peaks come at about 08:00 AM.

Table 14. Correlation coefficient between larva plus nymph, adult and total *Amblyomma cohaerens* and minimum temperature, maximum temperature and relative humidity

	min. temp.	max. temp.	r. humidity
Larva + nymph	0.47 (**)	- 0.46 (**)	0.48 (**)
Adult	0.44 (**)	- 0.51 (**)	0.50 (**)
Total	0.47 (**)	- 0.51 (**)	0.51 (**)

** =All correlations are significantly different from Zero (P< 0.01)

Table 15. Correlation coefficient between larva plus nymph, adult and total *Boophilus decoloratus* and minimum temperature, maximum temperature and relative humidity

	min. temp.	max. temp.	r. humidity
Larva + nymph	0.51 (**)	- 0.40 (**)	0.44 (**)
Adult	0.44 (**)	- 0.59 (**)	0.59 (**)
Total	0.50 (**)	- 0.53 (**)	0.54 (**)

**= All correlations are significantly different from Zero (P< 0.01)

4.4. Agro-ecological effect on tick population

Movement by engorged female ticks is influenced by groundcover and temperature, when seeking site suitable for oviposition. After hatching from the egg, larvae travel only short distances to locate and ascend on vegetation in which they await a passing host. Hunting or migration in the direction of a host animal is a response to the emission of Co_2 and heat radiation from the host's body.

Like many other hard tick species, *Amblyomma cohaerens* and *Boophilus decoloratus* can passively await a host on vegetation. Certain plant associations support higher tick populations than others. With the approach of a host, perceived by mechano and photoreceptors of the tick, a questing posture, with forelegs extended, is assumed. If host contact is not made the tick returns to a passive posture with its forelegs folded under the body.

Considering the factors contribute to the infestation of forage areas with ticks, while these organisms are obligate ectoparasites, it is unlikely that they existed on pastures before the presence of host animals. *Amblyomma cohaerens* and *Boophilus decoloratus* attacks a wide spectrum of host animals in addition to cattle. Cattle are the most preferred host for all instars of ticks and are an essential component of the host spectrum for larvae and nymphs in forage areas. This means that bovine hosts play the major role in the diffusion of engorged females in pastures, and consequently influence the dispersion of larvae in these situations. In the southwestern region, which includes Jimma, farmers utilize forested pastures as forage areas for cattle. The populations of ticks in these areas grow quickly by exploiting the increased host availability. Farmers, in turn, are confronted with recurring and high levels of tick infestation on their cattle.

Rainfall and the directly related relative humidity are the main climatic factors influencing tick distribution and activity. A peak of activity for both species was detected at the beginning of the heavy rain (June-July).

Due to the extreme difference in rainfall and relative humidity during the year tick numbers during the dry season are low with a marked increase coinciding with the start of the rains. Relatively high tick burdens last throughout the rainy season.

Result from analysis of variance for larva plus nymph, adult and total *Boophilus decoloratus* and *Amblyomma cohaerens* table 16 and 17 indicate that site and month had a significant (P<0.01) effect on infestation.

Table 16. Analysis of variance for larva plus nymph, adult and total *Boophilus decoloratus*

	Larva + Nymph		Adult		Total	
Source	DF	F-value	DF	F-value	DF	F-value
Year	1	0 NS	1	0 NS	1	0 NS
Site	4	71**	4	69 **	4	109 **
Month	11	40 **	11	36 **	11	54 **

** = P<0.01, NS = Not significant

Table 17. Analysis of variance for larva plus nymph, adult and total *Amblyomma cohaerens*

	Larva + Nymph		Adult		Total	
Source	DF	F-value	DF	F-value	DF	F-value
Year	1	1 NS	1	1 NS	1	0 NS
Site	4	70 **	4	59 **	4	86 **
Month	11	46 **	11	39 **	11	50 **

** = P<0.01, NS = Not significant

When we observe physical contact made by cattle and ticks in pasture, it obviously occurs by chance or as the result of programmed behavior in the host, the tick, or both. Simply stated, the probability of host tick contact is high, when both the host and the tick are at the same part of the pasture and when the tick is responsive to the presence of the host. The probability of contact is low when activity patterns in either organism do not coincide or when the tick does not respond to the presence of a host.

Tick numbers on local cattle are on the whole moderate to low on adults since they have developed high levels of host resistance to ticks. Crossbred cattle are known to be more susceptible to both ticks and tick-born diseases enabling tick populations to reach greater levels proportional to the level of exotic blood present in the animals. Tick burdens are related to the nutritional status of the cattle.

In areas with rain most of the year, there is suitable pasture available at all times-including those months before the rainy season and the animals tick resistance is high by the time of the rains, lowering tick number. Conversely, in areas of summer rainfall, there is a progressive deterioration in the condition of the cattle as the dry season sets in lowering their tick resistance. At the start of the rains the animals are at their lowest state both in terms of condition and tick resistance when the rise in tick burdens come.

Our observation on infestation rate of different breeds with *Amblyomma cohaerens* and *Boophilus decoloratus* noted that as compared to Holstein Friesian cattle, indigenous zebu supported fewer larvae, nymphs, and females at various stages of engorgement. Ticks removed from the indigenous cattle were lighter, females laid fewer eggs, and fewer immature ticks molted. The study on the host preference of tick to different breeds and blood groups showed that host selection and specificity correlate with the abundance and distribution of the tick. These have been reflected by the presence of more tick in highbred cattle from November to March than the indigenous zebu, which have almost nothing on.

5. Discussion

The tick population dynamics study done on cattle of Jimma zone identified eight species of four genera of ticks namely: *(B. decoloratus, A. cohaerens, A. variegatum, R. evertsi evertsi, R. praetextatus, R. bergeoni, R. lunulatus and H. aciculifer)*. The finding on the genera spectrum and species of ticks corresponds with the findings of Castro (1994) and Mekonnen (1996). *B. decoloratus* and *A. cohaerens* were the most dominant species throughout the year. The diversity of the tick species found on cattle is not very high and it is in line with pervious studies of Lall (1981) and Castro (1994).

Pegram *et al.,* (1981) and Castro (1994) recorded that *A. cohaerens* and *B. decoloratus* are widespread and abundant above the 800 mm rainfall line and rare below it. An unpublished survey report on tick distribution of Jimma zone (1996) showed that of the total collection of 8642 ticks in the area and rainfall range the two species counts 8211 (*Amblyomma cohaerens* 2852 and *Boophilus decoloratus* 5359). The rest 431 ticks were *A. variegatum* and *Rhipicephalus* species.

The abundance of *Amblyomma cohaerens* and *Boophilus decoloratus* in these areas is related to the presence of suitable vegetation cover. That is in agreement with the finding of Solomon and Kaaya (1998). They noted that brushy areas in pastures had high tick populations; where as improved pastures had low populations. Extraordinary densities of *Amblyomma cohaerens* and *Boophilus decoloratus* often result, in the southwestern Ethiopia where climatic factors, vegetation, and an abundance of host animals favor growth in populations.

Temperature and humidity measurement in the five localities indicated very high day temperatures and low humidity and considerable cooling and a raise in relative humidity during the night. High summer temperatures influence the behavior of adult ticks in all habitat types. This condition probably results in shorter longevity in some of the localities. As a behavioral response to rising temperatures during November to April, adults migrate down the vegetation to the soil.

During the night cooler month of October and November the morning peaks are delayed to late morning and late afternoon, while during the warmer month of April and May, the morning peaks come at about 08:00 a.m. Daily air temperature fluctuations may be the important factor controlling daily activity patterns of the tick *Amblyomma cohaerens* and *Boophilus decoloratus*. The percentage ascending remained constant until late July when ticks began go down to the soil in association with higher humidity and lower temperatures. Thus climatic factors seemed to greatly influence cattle tick infestation.

The ticks were found on the cattle every month of the year, but there was a reduction in the number of ticks per animal during the dry season. Rainfall was the climatic factor that most affected the seasonal variation in the tick infestations that is in agreement with the findings of Pegram *et al.,* (1982). Our result was consistent with those of Asres and Fissha (1991) who studied the tick fauna and seasonal dynamics at Abernosa ranch they found out that minimum temperature had higher effect than maximum temperature.

The study indicates that daily and seasonal activity patterns in cattle are relevant to patterns of both host finding and disengagement of ticks from the host. The type of pasture and the location of water sources influence patterns of usage of forage areas by cattle. The more variation in plant communities that exists on a pasture, the greater is the variation in usage by cattle. Furthermore, soil and season may affect acceptability of herbage to cattle, and cattle may feed on different parts of the plant structure at different times of the year similar to the observation of Wilkinson (1979).

Although ticks were present on the animals during the whole study period, two peaks of infestation could be distinguished between September 1998 and August 2000, each of which probably corresponded to a new generation of ticks. These data are in agreement with the observations of Solomon and Kaaya (1998) that studied the development reproductive capacity and survival of *Amblyomma variegatum* and *Boophilus decoloratus* in relation to climatic factor and host resistance under field condition and noted the occurrence of two generations of the tick per year.

The degree of infestation of the animals with larvae is related to the influence of climatic factors on the production and survival of the non-parasitic stages. Hence the seasonal variation of ticks on the animals presented a direct association with the availability of larvae in the pastures, which is in agreement with the observation of Sutherst (1989) i.e. during the months of low infestation the population of larvae available in the pastures is relatively low.

The growth and multiplication of all instars of *Amblyomma cohaerens* and *Boophilus decoloratus* were correlated with mean air temperature. The habitat most favorable for it was also most moderate in terms of temperature and relative humidity. Consequently, the environmental conditions created within a pasture, specifically temperature and relative humidity, are more important for the survival of *Amblyomma cohaerens* and *Boophilus decoloratus* than plant species comprising that grazing field.

Thus, when temperature is low and relative humidity high in May, June and July, population of Amblyomma *cohaerens* and *Boophilus decoloratus* ascends vegetation and awaits a host. When temperature is high and relative humidity low from November to March, ticks descend the vegetation and seek shelter in the soil and leaf litter. Both *Amblyomma cohaerens* and *Boophilus decoloratus* seek hosts by moving across the ground from November to March and in May, June and July by ascending on vegetation.

Rainfall appeared to be the climatic factor that most influenced the seasonal variation in the intensity of infestations of *A. cohaerens* and *B. decoloratus* in the study area during the study period. Peaks in the number of ticks were preceded by rainfall, as observed by Wilkinson (1979). In South Africa, Robertson (1981) found out that a monthly rainfall of 100 mm/month or lower created unfavorable conditions, resulting in a gradual fall in the numbers of available larvae. In our study, it was found out that only monthly rainfall in excess of 250 mm at the end of July and August produced a reduction in *A. cohaerens* and *B. decoloratus* infestations.

An increase was observed in the number of ticks from May to July 1999 and 2000, immediately following the beginning of the rainy season. During the dry season (November to April), when rainfall and humidity were lower, there was a sharp reduction in *A. cohaerens* and *B. decoloratus* infestations, producing the lowest counts in the observation period. A small peak occurred in September to October 1998 and 1999 that can probably be related to the increase of temperature and reduction of rainfall that occurred in these months. These data confirm the observation of Gray and Potgliter (1982). The onset of the rainy season (May-June) produced a rise in infestation levels, which then remained relatively high until July, when there was a reduction that was probably due to excessive rain.

The fluctuations in infestation levels showed the same pattern during both years of the study although the peaks were of slightly different intensities. Lall (1981) observed that heifers and young bulls of highbred cattle presented higher burdens of *A. cohaerens* and *B. decoloratus* than did adults and calves, although Teel *et al.,* (1988) did not find any age-related effect on resistance to the tick. In the our study, both the climatic differences between the two years and the cattle-raising techniques used by the farmers where the study was carried out couldn’t lead to the infestations defference in the animals.

When assessing the response of cattle to tick infestation in the study areas variation between the age groups, breeds and different management systems were observed. Adult animal show less burden to tick infestation consequently to tick born diseases, some young animals show enhanced resistance and immunity to tick-born diseases for a variable period particularly those their mothers were immune. Infections during this period are usually symptom less and vague, with additional boosting infections and are able to produce life long immunity. In local cattle stability is ensured when the entire cattle population is immune because of early natural exposure to the disease. There are no clinical cases but the disease organism is widespread. Enzootic stability is a vital natural resource, which should not be lost by over-enthusiastic tick control.

Instability occurs when a proportion of a population remains unexposed to tick-born diseases for too long because of acaricide treatments or keeping calves in yards until they are over 6 months of age. Tick-born diseases, with very serious mortality to morbidity, may occur in these animals as they age.

When tick-born diseases exist, reducing tick numbers below a certain level may disrupt a situation of enzootic stability, leading to greater production losses. Not all types of cattle can attain a state of enzootic stability with all tick-born diseases, and breeds differ in their resistance to ticks. In general, high productive breeds are more susceptible to both ticks and tick-born diseases, and less likely to attain enzootic stability. It is now apparent that ticks and tick-born diseases in south-west Ethiopia are in equilibrium with the predominant local cattle present in the region in a situation know as enzootic stability. However, this equilibrium may be broken when improved dairy cattle are introduced with out analyzing the situation.

Tick control in Ethiopia should be based on a thorough knowledge of tick ecology and tick-born disease epidemiology. Tick control needs difference between those of indigenous zebu animals and improved crossbred cattle. While tactical acaricide application to keep tick population levels down may only be needed in the former, a carefully formulated strategy of acaricide use and monitoring probably complemented with immunization against tick-born diseases is needed for the later, in order to prevent losses due to ticks and tick-born diseases.

Therefore, since the government's policy of livestock improvement in the dairy sector is targeted on improved exotic breed to the whole of the country, measures to control ticks and tick born diseases on these animals should consider the agro-ecology of the area, since it may not be similar nation wide. The choice of the most appropriate strategy is dependent on the epidemiological and economic characteristics of the cattle production system in each situation.

6. Conclusion

6.1. Cattle tick control management proposal for Jimma zone

In Jimma zone because of the climatic condition that favors their development ticks give a continuous and substantial challenge to cattle especially between April and October and become difficult to control. In dry season ticks spend a lot of time off the host and in wet season its generation's overlap and the numbers in pasture are often high.

Amblyomma cohaerens and *Boophilus decoloratus* were the dominant tick species in Jimma zone. Other species were of least importance in the zone. It was determined that if acaricide adequately and properly applied on cattle at a regular interval it can control the almost all abundant tick species of the zone. Therfore, the application of acaricide should be based on the information on the population and seasonal dynamics of ticks of the region.

From the result obtained, it was also found that crossbreds were more susceptible to tick infestation in all the study period than the local *Zebu*. Therefore, application of anti tick treatment should also consider the breed type and the level of exotic blood in cattle. In general, to make cattle less attractive to ticks or to develop breeds that are able to defend ticks has less importance; the best solution would be the combination of pasture management, animal management and acaricide use strategy.

Pasture management

In Jimma zone ticks spend about 80 % of their lives in pasture. Poorly drained pasture with bushes and shrebs are often associated with high tick numbers. Long pasture even in well drained areas, will also harbor ticks, but by improving drainage and keeping pastures topped or grazed, humidity on the sward will be kept down making conditions less favorable for tick egg to hatch or for engorged ticks to molt.

Pasture keeping free from cattle will not work in Jimma zone because most of tick species of importance have other hosts and also the grazing areas are scarce to keep it open until the free living stage died. The general practice to burn the pasture once in a year, both to improve the pasture and to control tick population have significant role in reducing tick population. To cultivate grazing areas for two consecutive years and use previously cultivated area for pasture have significant rolls in the reduction of cattle tick infestation.

The technique known as “vacuum cleaning” works in areas like Jimma zone where there is no other place for grazing unless zero grazing is practiced. This method involves letting grazing stock (preferably older animals) on tick-infested pasture for up to 3 days, for a period that gives tick time to attach, but not to complete their feeding, and drop off back in to the pasture. These stocks are then treated and replaced on the same pasture with another mob of undipped animals.

By systematically working over one highly infested paddock at a time, and by introducing as many mobs of animals as necessary, ticks will be depleted. The number of mobs needed depend on how many ticks are seen after the first two or three grazing. The paddock is left open for about 4 weeks and the “vacuum cleaning” repeated to remove any remaining ticks. This method has been practiced in the campus of college of agriculture and plays significant roll to reduce tick burden.

Animal management

In Jimma zone relatively few very susceptible hosts within the herd harbor the majority of ticks. Those few animals are responsible for maintenance and transmission of the parasite population to the more resistant animals. The control of ticks by natural host resistance can be achieved if at all the resistant phenotype could be selected. To select cattle with high degree of resistance to tick infestation particularly within zebu breeds is important.

Breeding cattle that are tick-repellent will not only reduce the tick population in the area because fewer fully engorged females drop from them, but they are also a much better economic proposition than the susceptible high yield cattle, because they grow better, have higher calving percentage and are bred for functional efficiency. As part of animal management, an appropriate strategy such as minimal control in period of low challenge November to March and strategic control for high seasonal challenges from April to October can be considered. These three options for control can be applied:

- Intensive spraying of highly productive, dairy cattle with more than 50 % of exotic blood (*Bos taurus*) are likely to continue to require intensive tick control even though they represent only a small number and not justifiable to areas like Jimma.

- Strategic tick control would appear to be economically and ecologically feasible in most farming situations using a cross bred of cattle that has less than 50 % exotic blood based on the seasonality of ticks.

- Minimal or threshold tick control to maintain the enzootic stability or to re-establish. The treatment is only at times of very heavy tick challenge. This is more applicable to local breed of cattle. It is known that indigenous dual-purpose breeds are highly resistant to tick, resulting in low infestation rates that cause insignificant direct losses.

If we keep local indigenous cattle completely tick free they become similarly susceptible and any disruption of intensive control regimens can have disastrous effects. Therefore maintaining the threshold is essential.

At the same time to educate farmers on the effect of ticks and tick born diseases and also inform on the importance of reduced acaricidal control of ticks in order to establish or maintain enzootic stability and on production of safe livestock product. In addition, encourage community to practice safe and economical traditional control methods, as part of integrated tick management is essential.

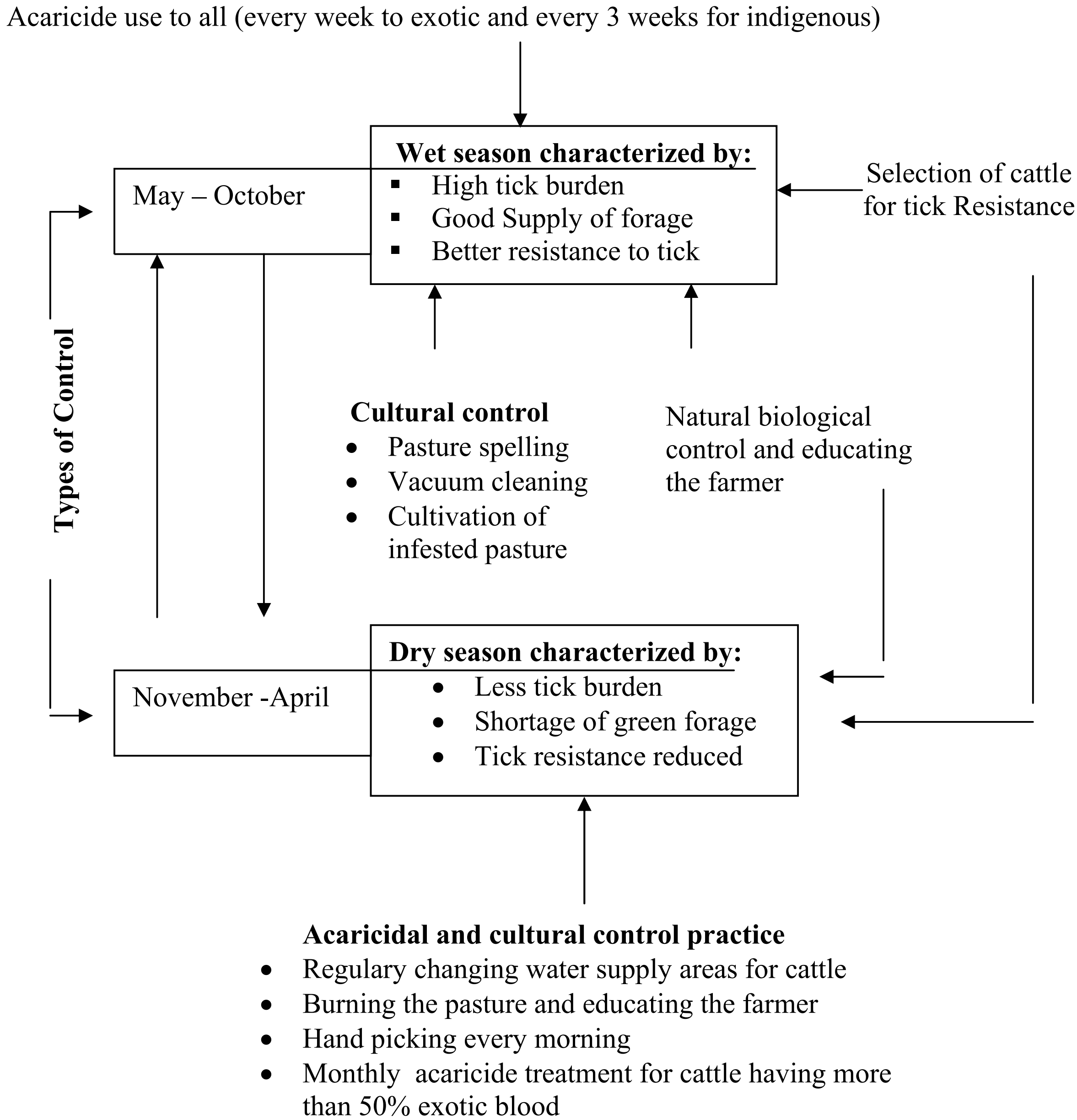


Figure 21. Recommended cattle tick management in Jimma zone

The general principles of tick and TBD control in Jimma zone should be based on:

- Preserve enzootic stability through minimal or threshold tick control or re-establish it through immunization against TBD
- Assess the comparative advantage of using different cattle breeds and select the exotic blood level of highbred.
- Educate farmers and extension agents to accept the benefits gained from both boosting immunity to TBD and achieving host resistance to ticks that would result from relaxed tick control regimes.
- Use appropriate strategies, such as minimal control in period of low challenge (November to April) and strategic control for seasonal high challenges (May to October).
- Adjust animal husbandry practice based on defense reaction of the animal against tick and tick born diseases.
- Institute tick control regimes based on sound economic thresholds and environmental protection and should be advocated to be included in the regional agricultural and environmental law.

6.2. Countrywide tick control management recommendation

Eradication of ticks in countries like Ethiopia is generally not feasible and unrealistic. Therefore, we should be looking forward to a situation where cattle are living with these ectoparasites. In general, it is more efficient to allow livestock to collect ticks and then kill the parasites on the host, rather than to apply acaricides to pastures a practice which is also potentially much more harmful to the environment. Intensive dipping or spraying programs have been largely unsuccessful in eradicating ticks. Integrated tick control strategies have been advocated, based on host resistant to ticks and the diseases they transmit strategic tick control taking in to account the seasonal dynamics of tick infestation, the availability of vaccines against tick born diseases and cost/benefit analysis of acaricidal application.

Moreover accurate data on tick ecology (geographical distribution, seasonal occurrence and host preference) are also required together with data on the prevalence of tick-born diseases within both traditional and commercial cattle production systems. Epidemiological data on tick born diseases should be related to ecological data as a basis for a recommended tick control program.

In order to safe guard the utility of the chemicals, which are currently available in Ethiopian market for tick control, rational tick control strategies are needed to manage resistance. These strategies must be designed to both prolong the effectiveness of current acaricide and reduce the environmental impact of using these substances. It should be based on integrated tick management techniques, which exploit the biology of ticks being controlled. However, ticks can be expected to evolve strains, which are also resistant to various new control agents, and it is therefore, paramount that veterinarians using acaricides apply these materials judiciously to maintain the stock of tick control option in the future. Drug importers have the responsibility to adjust marketing plans to protect the useful life of a product and should therefore encourage the integration of strategies, which should tend to prolong the life of available acaricide and delivery system.

Impact assessment of tick and tick born diseases and their control is an increasingly important consideration in the light of ever more scarce resources, and should be incorporated into tick and tick born disease control programs to ensure their long-term viability. The scope of impact assessment is changing rapidly; as we are just starting to incorporate economic evaluation into our control strategy, the demand for broader evaluation of poverty alleviation, enhanced food security and environmental protection are becoming increasingly important for the country.

Eventhough the practice is highly expensive, there is a rich experience in tick management in the Caribbean that can be tried in our condition by modification and selection the less costly methods. This reliance on the active participation of community that has been successfully reinforced through intensive public information and sensitization programs.

In these management practices the participation expected from the community has been divided into two categories:

- In the infested areas, all animal owners are required to register their animals and treat them regularly once every two weeks for two years.
- In the non-infested areas, all communities are urged to inspect their animals for the presence of ticks and report any findings to the veterinary service.

Collaborative efforts have been established between the new and the ongoing program. In addition to the exchange of communication materials, close collaboration in the production of some items has been established to avoid duplication. The different treatment methods do not affect the objective of tick eradication that is common to both programs. The acceptance of the farmers' responsibility for the Flumethrin "pour on" pesticide treatments has been outstanding, with over 80 % compliance. Moreover, there has been a rapid increase in gaining the confidence of the livestock industry and numerous farmers have reverted to cattle rearing.

This strategy can be applied in Ethiopia with modification of the implementation strategy based on the available resources. Our implementation strategy should consider the degree of risk, depending on the distribution and prevalence of tick species and classify the areas in to:

- Low and medium risk areas that need activities like public information dissemination and community awareness campaigns on tick species and their economic impact. Training to enhance surveillance activities, coupled with an effective quarantine system.

- High risk areas that need actual tick control activities like mandatory systematic and sequential acaricide treatments of all livestock by the farmers themselves, information dissemination and training to maximize community participation, restrictions on the movement of livestock and improved quarantine and biological monitoring and long-term surveillance.

Future approaches of ticks and tick-born diseases control in Ethiopia should revise the technologies. Technologies for the control of ticks and tick-born diseases in Ethiopia still need improvement but many are now at the stage where, if correctly applied, they can have a major impact on reducing the deleterious effects of ticks and tick-born diseases. There are many aspects of tick biology and ecology that are affected by management strategies differing between the production systems. Surveillance should focus on both target and non-target species in order to assess the over all risk. Acaricidal use, breeding for host resistance, ecological/biological control and immunization all the program should be integrated in the whole management program of the country. Thus, the technology should take the following factors into consideration in selecting control programs:

Reliability: - Reliance must not be placed on a single approach to control ticks and tick-born diseases. Integrated approaches required which combine an appropriate balance between tick control, vaccination, chemotherapy and management. Veterinary and other delivery services must be sufficiently effective and reliable to provide these inputs and back-up at the time that they are needed.

Affordability:- No farmer is prepared to pay for inputs the costs of which exceed the possible benefits that might accrue. Since control of tick-born diseases is largely of benefit to the individual animal owners and is only of indirect benefit to the public good, it is increasingly felt that it is the beneficiaries (farmers) who should pay for control, rather than national governments which need to priorities expenditure ever more strictly within their declining budgets. It is clear that the whole economic strategy of tick and tick-born diseases control needs a major re-appraisal if a sustainable system is to emerge within the current economic environment of Ethiopia.

Tick control:- As a consequence of cost, the practice of regular tick control is not possible for many farmers in Ethiopia. Furthermore, it is now clear that for many situations total elimination of ticks is not a desirable aim, since it removes the element of challenge to tick-born diseases, which is required to establish and maintain enzootic stability to the diseases.

Availability:- Because of poor communications in many parts of Ethiopia, there are problems in getting drugs, vaccines and acaricides to farmers. There are at present many weak links in the delivery chain from importers to end-user and, in each region; the nature of the problem is different. In general, delivery programs which rely on the government sector are weak and attention should be turned to the commercial companies, the private sector and even non-governmental organizations (NGOs) which often have their own communication networks and delivery chains which are not subject to the same constraints that national delivery programs sometime face.

Appropriateness:- Farmers' perceptions of their needs and priorities in terms of disease control are not always in line with those of veterinary authorities. In order that more appropriate control methods of tick and tick-born diseases control can be developed, more attention needs to be given to understanding farmers' needs and priorities. This can be done by improving extension linkages and communications with farmers, and adopting participatory appraisal methods to involve farmers in decision-making.

It is also important that tick and tick-born diseases control methods become recognized and accepted as an appropriate part of an integrated package of improvements aimed at increasing livestock productivity and not as stand-alone interventions.

Sustainability:- In order for the methods that farmers adopt for control of ticks and tick-born diseases to be sustainable, all the above criteria of reliability, affordability, availability and appropriateness must apply. This is most likely to be achieved if a package of balanced technology is adapted which are integrated in to the particular farming system being practiced. Furthermore, in adopting such technologist the farmer must see the benefits in terms of improved productivity, increased profits or reduced risk and costs.

However, uptake of this technology is slow, and programs must in the future focus more on delivery than on technology development. If the technologies are to be adopted, policy makers, veterinarians and farmers have to perceive them as reliable, affordable, available, appropriate and sustainable.

7. Summary

In Jimma zone southwestern Ethiopia where the mainstay of the people is coffee and livestock production. A study was conducted to establish spectrum, burden and seasonal dynamics of ticks on indigenous and exotic cattle breed in view of the development of management plan for tick and tick born disease control. Data was collected from college of agriculture dairy farm and from cattle's of the surrounding district farmers. Two different studies have been horizontally conducted: population dynamics study throughout the zone and seasonal dynamics study in five localities around Jimma town.

In the population dynamics study a total of 19672 ticks from 963 cattle have been collected and eight different tick species with the abundance of *A. cohaerens* 62 %, *B. decoloratus* 33 %, *A. variegatum* 3.8 %, *R. evertsi evertsi* 0.9 %, *R. praetextatus* 0.19 %, *R. bergeoni* 0.06 %, *R. lunulatus* 0.035 % *and H. aciculifer* 0.012 % were identified. The two species *Amblyomma cohaerens* and *Boophilus decoloratus* were the most abundant ticks in all the seasons.

In the seasonal dynamics study fifty cattle from five localities were selected and monthly tick collection performed for two consecutive years (from September 1998 to August 2000) repeatedly. The study result indicates that ticks were present on the animals during every month of the year but there was a reduction in the number of ticks per animal during the dry season. Rainfall was the climatic factor that most affected the seasonal variation in tick infestation.

The fluctuations in infestation levels showed the same pattern during both years of the study, although the peaks had different intensities. When the cattle were grouped according to the exotic blood level the cattle with a preponderance of exotic blood presented a significantly greater infestation than those with little predominance of indigenous zebu genes.

The growth and multiplication of all instars of *Amblyomma cohaerens* and *Boophilus decoloratus* were correlated with mean air temperature. Both *Amblyomma cohaerens* and *Boophilus decoloratus* had two peaks of activity, in September and October (moderate) and in May, June and July (maximum). No significant increase in tick population was observed during the short rains February/ March. There was, however, a greater buildup coincidence with the main rainy season. There was a direct relationship between population and minimum temperatures, whereas maximum temperature seemed to have no such relationship.

It is apparent that ticks and tick-born diseases in south-west Ethiopia are in equilibrium with the predominant local cattle present in the region in a situation know as enzootic stability. Therefore, with this situations eradication of ticks in countries like Ethiopia is generally not feasible and unrealistic. Intensive dipping or spraying programs have been largely unsuccessful in eradicating ticks. Integrated tick control strategies should be advocated, based on host resistant to ticks and the diseases they transmit. Strategic tick control sould be designed by taking in to account the seasonal dynamics of tick infestation, the availability of medicines and vaccines against ticks and tick born diseases and cost/benefit analysis of the strategies.

In Jimma zone because of the climatic condition that favors their development ticks give a continuous and substantial challenge to cattle especially between May and October and become difficult to control. In general, to make cattle less attractive to ticks or to develop breeds that are able to defend ticks has less importance; the best solution would be the combination of pasture management, animal management and acaricide use strategy. As part of animal management, an appropriate strategy such as minimal control in period of low challenge November to April and strategic control for high seasonal challenges from May to October can be considered.

8. Zusammenfassung

Im Gebiet von Jimma, im Südwesten Äthiopiens hängt der Lebensunterhalt von Kleinbauern, hauptsächlich von Kaffee und Tierproduktion ab. Die Studie wurde durchgeführt, um Informationen über die Belastung von Rindern mit Zecken, und deren Artenspektrum sowie jahreszeitliche Aktivität bei autochthonen Zeburassen, exotischen Rindern und deren Kreuzungen zu erhalten.

Für diese Untersuchung wurden jeweils Tiere sowohl einheimischer als auch exotischer Rassen aus dem Milchkuhbestand der landwirtschaftlichen Hochschule Jimma und aus den Viehbeständen von Landwirten der Umgebung genutzt. Das Endziel der Untersuchung sollte die Entwicklung eines Managementplans zur Kontrolle von Zecken und der durch Zecken übertragenen Krankheiten sein.

Untersuchungen zur Populationsdynamik der Zecken wurden von September 1998 bis August 1999, also für die Dauer eines Jahres, durchgeführt. Im Laufe dieser Untersuchungen wurden 19672 Zecken gesammelt und identifiziert. Acht Arten, namentlich *A. cohaerens* 62 %*, B. decoloratus* 33 %*, A. variegatum* 3,8 %, *R. evertsi* 0,9 %, *R. praetexatus* 0,19 %, *R. bergeoni* 0,06 %, *R. lunulatus* 0,035 % *und H. aciculifer* 0,012 % wurden gefunden. Zu allen Jahreszeiten waren *Amblyomma cohaerens* und *Boophilus decoloratus,* die am häufigsten nachgewiesenen Spezies.

Zur Untersuchung der Saisonalität wurden jeweils fünfzig Rinder aus fünf Gegenden ausgewählt. Von diesen wurden im Laufe von zwei Jahren jeden Monat von September 1998 bis August 2000 Zecken gesammelt. Die Zecken wurden am Körper der Tiere während jedes Monats des gesamten Jahres gefunden. Die Zahl der Zecken je Tier war in der Trockenzeit geringer. Regen ist der wesentlichste Einflussfaktor, für die jahreszeitliche Variation des Zeckenbefalls. Die Variation des Befallsgrades zeigte das gleiche Muster während der beiden Jahre der Untersuchung. Die Spitzenintesitäten waren jedoch deutlich unterschiedlich.

Wenn die Rinder entsprechend ihres Gehaltes an exotischen Blutbeimischungen in Gruppen aufgeteilt wurden, zeigte sich, daß bei den Tieren mit überwiegend exotischer Blutbeimischung der Befall deutlich höher war, als bei Tieren der überwiegend einheimischen Zeburasse.

Sowohl Vermehrung als auch Wachstum aller Zwischenstadien von *Amblyomma cohaerens* und *Boophilus decoloratus* sind abhängig von den mittleren Umwelttemperaturen. Sowohl *Amblyomma cohaerens* als auch *Boophilus decoloratus* zeigten zwei Spitzen-Infestationraten, eine mäßige im September und Oktober, sowie eine maximale in Mai, Juni und Juli.

Die Vermehrung der Zeckenpopulation während der kurzen Regenzeit Februar/März war unbedeutend. Zu einer erheblichen Steigerung des Befalles kam es während der Hauptregenzeit von Mai bis September. Es besteht offenbar eine Beziehung zwischen der Populationsmenge der Zecken und der minimalen Tagestemperatur. Die maximale Tagestemperatur schien dagegen keinen Einfluss zu haben.

Es erscheint nahe liegend, daß Zecken und durch Zecken übertragbare Krankheiten im Südwesten Äthiopiens in gleichem Maße bei den untersuchten Rindern in der gleichen Region zu erwarten sind. Eine solche Situation ist durch enzootische Stabilität gekennzeichnet. Aus diesem Grunde erscheint eine Ausrottung von Zecken in Ländern wie Äthiopien weder erforderlich noch realistisch. Die bislang in großem Umfang durchgeführten Tauch- und Spritzprogramme waren letztlich erfolglos.

Eine Strategie zur Kontrolle der Zeckenpopulation muß auf eine Stärkung der Widerstandsfäigkeit der Wirte gegen Zecken und die durch diese übertragene Krankheiten zielen. Im Hinblick auf die jahreszeitliche Aktivität des Zeckenbefalls sollte die Verfügbarkeit von Medikamenten und Impfstoffen gegen die von Zecken übertragenen Krankheiten Basis für eine zeitlich und ökonomisch sinnvolle Strategie sein.

In Anbetracht der im Untersuchungszeitraum festgestellten geringen Infestationsraten bei einheimischen Rindern in der Region Jimma, erscheint eine Zeckenbekämpfung weder unter wissenschaftlichen noch unter wirtschaftlichen Gesichtspunkten sinnvoll.

In der Region Jimma hat, wie gezeigt werden konnte, das Klima einen entscheidenden Einfluss auf die Vermehrung und Entwicklung der Zecken. Die besonders hohe Befallsrate durch Zecken von Mai bis Oktober erschwert die Kontrolle. Im Allgemeinen erscheint es wenig sinnvoll, zu versuchen, die Befallsrate der Rinder zu verringern oder aber Züchtungen zu verwenden, die für den Zeckenbefall weniger empfänglich sind.

Als beste Lösung erscheint eine Kombination aus geeigneter Weidewirtschaft und Nutzung von Akariziden. Für die Tierzucht sollte eine geeignete Kombination aus minimaler Verwendung von Akariziden zu Zeiten geringen Befalls (November – April) und einer vermehrten Verwendung von Akariziden zu Zeiten höheren Befalles (Mai – Oktober) in Erwägung gezogen werden.

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11. Lebenslauf

Persönliche Daten

Name:	Abebaw Gashaw Kebede
Geburtsdatum:	Juli 17 1960
Geburtsort:	Gojjam, Äthiopien
Geschlecht:	Mann
Familienstand:	Verheiratet
Nationalität:	Äthiopien

Ausbildung

1965-1970	Grundschule
1970-1978	Oberschule
1978-1980	Veterinärmedizin Fachschule
1984-1988	Veterinärmedizin Ausbildung (DVM)an der Leipzig Universität, Abteilung der Tierproduktion und Veterinärmedizin
1994-1996	Aufbaustudium an der Fakultät für Agrarwissenschaft, Georg-August Universität Göttingen
1997-2004	Doktorand an der Fakultät für Agrarwissenschaft, Georg-August Universität Göttingen

Arbeit Erfahrung

1980-1983	Labortechnische Unterstützung im Jimma Institut der Landwirtschaft
1988- 1994	Dozent und leitet der Abteilung Tierproduktion an der im Jimma Institut der Landwirtschaft
1998- 2004	Dozent und Koordinator des Weiterbildungsprogramms der Jimma Universität, Äthiopien

12. Appendices

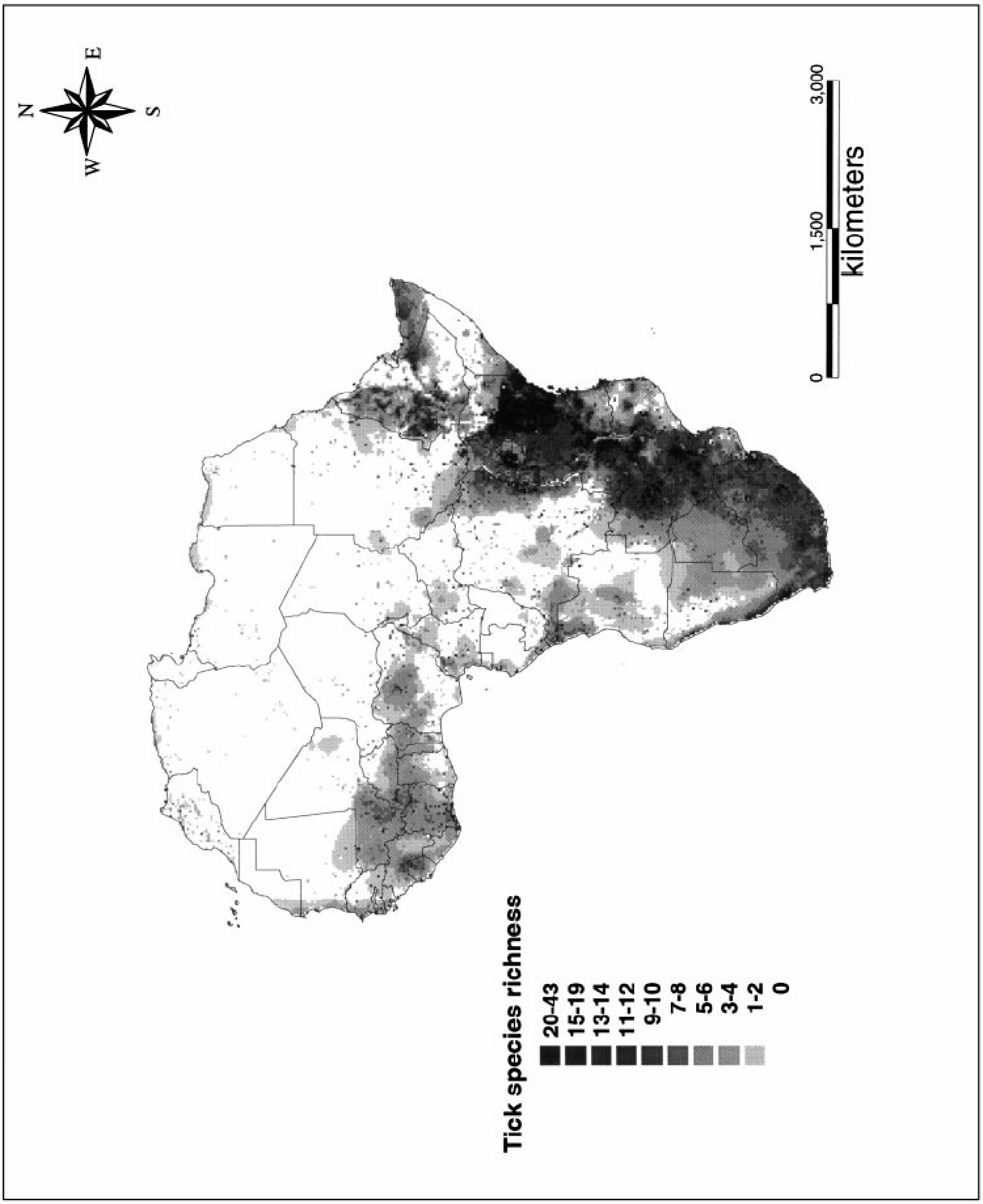
Annex 1. Least squares means for larva+ nymph, adult and total *Amblyomma coherence* in different months for the 1998/99 and 1999/2000

Month	Larva+ Nymph	Adult	Total
September	49	65	114
October	48	60	108
November	15	41	56
December	6	14	20
January	10	13	23
February	16	15	31
March	31	15	46
April	44	31	75
May	72	47	119
June	67	70	137
July	55	79	134
August	45	43	88

Annex 2. Least squares means for larva+ nymph, adult and total *Boophilus decoloratus* in different months for the 1998/99 and 1999/2000

Month	Larva+ Nymph	Adult	Total
September	184	127	311
October	123	196	319
November	36	113	149
December	19	17	36
January	32	29	61
February	44	40	84
March	74	57	131
April	110	88	198
May	176	174	350
June	170	199	369
July	174	199	373
August	141	124	265

Annex 3. Pan African tick species distribution (73 Species collected and prediction)



Annex 4. Thirty years summery of meteorological data

Location: - Jimma weather Station Year: 2000
Latitude = 7^o 4' N Longitude = 36^{o}E Altitude 1705M

Month	Rain Fall (mm)		Rainy days (N$^{\underline{o}}$)		Air Temperature (^{o}C) AR 2m				Soil Temperature (o^C)					
					Minimum		Maximum		Surface		10cm. depth.		20cm. depth	
	2000	Mean 1968-99	2000	Mean 1968-99	2000	Mean 1969-99	2000	Mean 1969-99	2000	Mean 1969-99	2000	Mean 1976-99	2000	Mean 1976-99
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Jan.	6.1	(33.1)	2	(6)	7.5	(8.9)	29.3	(27.4)	10.5	(8.2)	22.5	(21.4)	22.6	(21.2)
Feb.	32.8	(53.8)	8	(10)	8.6	(10.3)	30.3	(27.9)	11.9	(9.7)	23.5	(22.5)	23.5	(21.8)
Mar.	97.0	(96.8)	10	(13)	14.7	(12.0)	31.2	(27.9)	17.2	(11.2)	25.4	(23.1)	25.2	(22.7)
Apr.	214.1	(120.1)	19	(14)	14.4	(12.8)	27.5	(27.3)	15.3	(12.1)	22.7	(23.7)	23.1	(23.1)
May.	125.4	(184.5)	20	(19)	15.1	(13.1)	26.4	(26.3)	15.0	(8.6)	22.7	(23.4)	22.7	(22.8)
Jun.	176.9	(215.1)	21	(21)	14.0	(12.3)	24.6	(24.6)	14.7	(12.4)	21.8	(22.1)	22.2	(21.9)
Jul.	120.7	(231.1)	17	(23)	13.2	(12.7)	23.4	(22.9)	14.5	(12.3)	20.7	(20.7)	20.9	(20.7)
Aug.	193.7	(224.1)	24	(24)	14.0	(12.8)	23.6	(23.2)	14.6	(12.4)	20.7	(21.1)	20.8	(20.9)
Sep.	133.3	(194.8)	13	(20)	14.7	(12.4)	24.9	(24.4)	14.4	(11.9)	22.0	(22.2)	22.0	(21.7)
Oct.	43.8	(100.9)	9	(11)	15.3	(10.6)	25.7	(25.5)	13.3	(10.1)	21.9	(23.0)	21.8	(24.4)
Nov.	35.1	(53.2)	6	(6)	11.2	(8.6)	26.8	(26.3)	12.7	(7.9)	21.5	(22.3)	21.7	(21.9)
Dec.	114.7	(29.2)	12	(4)	8.7	(7.8)	27.4	(26.9)	13.9	(7.1)	20.9	(21.4)	21.2	(21.3)
Total	**1293.[illegible]**	**(1536.5**			**151.4**		**321.1**				**266.4**		**267.7**	
Mean			**13**	**(14)**	**12.6**	**(11.2)**	**26.8**	**(25.9)**	**14.0**	**(10.3)**	**22.2**	**(22.2)**	**22.3**	**(21.9)**

NOTE: - data in brackets are means of the months of the years indicated

Annex 4. Continued

Month	Relative humidity (%)		Sunshine (Hours/month)		Radiation (Cal/cm^2)		Evaporation clas (mm/month)		Wind speed (km/Hrs)	
	2000	Mean 1973-99	2000	Mean 1969-99	1993	Mean 1981-92	2000	Mean 1969-99	2000	Mean 1977-99
16	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**
Jan.	63	(57.3)	8.2	(6.8)	395.3	(383.1)	5.07	(4.64)	2.14	(2.42)
Feb.	57	(57.6)	7.5	(6.2)	374.2	(386.8)	5.12	(4.98)	2.80	(2.68)
Mar.	62	(61.0)	7.7	(6.0)	373.9	(412.7)	5.50	(5.27)	2.73	(3.12)
Apr.	65	(62.5)	5.7	(6.0)	411.4	(397.3)	3.91	(5.55)	2.41	(2.95)
May.	73	(68.3)	7.3	(5.5)	440.8	(386.7)	4.84	(4.79)	2.21	(2.91)
Jun.	77	(74.3)	7.0	(4.4)	411.9	(389.0)	4.30	(4.02)	2.57	(2.74)
Jul.	79	(79)	3.0	(2.9)	403.4	(338.9)	2.81	(3.37)	2.11	(2.40)
Aug.	80	(79)	4.1	(3.7)	411.4	(349.8)	3.66	(3.37)	2.64	(2.22)
Sep.	76	(76)	6.6	(4.9)	445.6	(409.4)	4.45	(4.25)	2.79	(2.37)
Oct.	69	(69)	7.6	(7.2)	447.7	(398.1)	4.79	(4.66)	2.30	(2.48)
Nov.	60	(69)	7.6	(7.7)	490.6	(385.3)	4.43	(4.69)	2.34	(2.46)
Dec.	62	(63)	7.4	(7.7)	427.61	(370.1)	4.23	(4.51)	2.37	(2.43)
Total	**823**									
Mean	**68**	**(68.0)**	**6.6**	**(5.8)**	**421.7**	**(383.9)**	**4.43**	**(4.45)**	**2.37**	**(2.62)**

NOTE: - Data in brackets are means of the months of the years indicated

Annex 5. Meteorological data of the study years

Jimma: - Mean monthly minimum temperature

Year	Sept	Oct	Nov	Dec	Jan.	Feb	Mar	Apr	May	Jun	Jul.	Aug	Ann. total	Ann. mean
98/99	13.0	13.0	13.6	11.3	12.4	12.4	13.9	14.0	15.1	13.5	13.7	13.8	159.7	13.31
99/2000	13.5	13.2	10.3	6.3	8.0	7.8	12.0	13.0	13.5	13.0	13.2	12.3	136.1	11.34

Jimma: - Mean monthly maximum temperature

Year	Sept	Oct	Nov	Dec	Jan.	Feb	Mar	Apr	May	Jun	Jul.	Aug	Ann. total	Ann. mean
98/99	26.1	26.0	26.2	26.6	27.1	28.1	27.8	29.2	26.3	25.5	22.9	23.5	315.3	26.28
99/2000	24.0	25.1	26.7	27.8	28.4	30.8	29.1	29.0	25.9	24.7	22.9	23.5	317.9	26.49

Jimma: - Mean monthly soil temperature 10cm. depth

Year	Sept	Oct	Nov	Dec	Jan.	Feb	Mar	Apr	May	Jun	Jul.	Aug	Ann. total	Ann. mean
98/99	22.9	22.2	21.7	22.7	21.7	22.4	23.2	24.7	23.1	21.9	20.5	20.3	267.3	22.28
99/2000	21.3	21.8	21.4	21.6	22.3	24.1	23.5	24.4	22.2	21.5	20.4	20.6	265.1	22.09

Jimma: - Mean monthly relative humidity %

Year	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Ann. total	Ann. mean
98/99	70	68	71	67	67	64	64	61	70	72	78	77	829	69.08
99/2000	76	72	59	49	51	41	51	57	68	74	80	79	757	63.08

Annex 6. Monthly distribution of *Boophilus decoloratus* tick year 1998/1999 total tick count

Larva + nymph												
Site	Septembe	Octobe	Novembe	Decembe	January	February	March	April	May	June	July	August
JCA	345	276	89	50	42	98	189	267	302	258	256	244
Blida	140	69	25	18	35	24	63	79	120	165	134	146
Jiren	137	88	29	21	30	31	36	67	96	139	164	129
Bore	179	110	21	10	34	23	24	57	167	143	185	121
Merewa	170	102	30	18	18	11	34	46	120	156	196	107
Adult												
Site	Septembe	Octobe	Novembe	Decembe	January	February	March	April	May	June	July	August
JCA	276	298	255	42	56	56	124	199	278	350	356	243
Blida	98	146	65	16	43	34	61	58	142	121	176	78
Jiren	87	112	76	24	23	45	35	45	153	144	158	89
Bore	91	156	54	18	21	42	45	65	168	200	167	113
Merewa	79	187	49	13	30	34	23	78	165	167	155	96
Adult + Larva + Nymph												
Site	Septembe	Octobe	Novembe	Decembe	January	February	March	April	May	June	July	August
JCA	621	574	344	92	98	154	313	466	580	608	612	487
Blida	238	215	90	34	78	58	124	137	262	286	310	224
Jiren	224	200	105	45	53	76	71	112	249	283	322	218
Bore	270	266	75	28	55	65	69	122	335	343	352	234
Merewa	249	289	79	31	48	45	57	124	285	323	351	203

Annex 7. Monthly distribution of *Amblyomma cohaerens* tick year 1998/1999 total tick count

Larva+nymph												
Site	Septembe	Octobe	Novembe	Decembe	January	February	March	April	May	Jun	July	August
JCA	92	76	35	21	11	38	67	78	99	101	91	76
Blida	31	33	12	8	6	12	34	34	67	46	33	41
Jiren	27	34	9	1	8	9	22	38	56	46	53	36
Bore	36	56	10	4	13	12	21	41	48	54	54	34
Merewa	44	45	14	8	8	2	20	28	63	76	39	24
Adult												
Site	Septembe	Octobe	Novembe	Decembe	January	February	March	April	May	Jun	July	August
JCA	111	124	87	43	32	34	36	67	78	89	102	72
Blida	44	49	34	22	8	12	6	36	42	62	65	47
Jiren	34	39	28	18	10	18	8	28	34	46	59	18
Bore	68	45	33	15	18	10	9	32	48	55	78	29
Merewa	77	47	18	11	20	12	10	21	36	76	96	44
Adult + Larva + Nymph												
Site	Septembe	Octobe	Novembe	Decembe	January	February	March	April	May	Jun	July	August
JCA	203	200	122	64	43	72	103	145	177	190	193	148
Blida	75	82	46	30	14	24	40	70	109	108	98	88
Jiren	61	73	37	19	18	27	30	66	90	92	112	54
Bore	104	101	43	19	31	22	30	73	96	109	132	63
Merewa	121	92	32	19	28	14	30	49	99	152	135	68

Annex 8. Monthly distribution of *Boophilus decoloratus* tick year 1999/2000 total tick count

Larva + Nymph												
Site	Septembe	Octobe	Novembe	Decembe	January	February	March	April	May	Jun	July	August
JCA	310	252	95	41	61	120	210	303	321	240	251	270
Blida	124	57	21	11	33	36	68	91	160	150	100	102
Jiren	115	88	25	11	30	48	47	74	118	141	113	91
Bore	154	101	13	3	28	32	36	68	204	152	176	105
Merewa	169	90	20	11	16	23	31	49	161	162	166	99
Adult												
Site	Septembe	Octobe	Novembe	Decembe	January	February	March	April	May	Jun	July	August
JCA	285	350	320	27	45	69	160	201	303	405	365	270
Blida	65	160	78	5	35	18	42	41	112	110	149	71
Jiren	93	135	81	12	12	51	40	32	128	145	185	67
Bore	122	200	75	4	11	24	26	66	144	188	148	106
Merewa	80	215	77	8	16	26	17	98	146	160	131	105
Adult + Larva + Nymph												
Site	Septembe	Octobe	Novembe	Decembe	January	February	March	April	May	Jun	July	August
JCA	595	602	415	68	106	189	370	504	624	645	616	540
Blida	189	217	99	16	68	54	110	132	272	260	249	173
Jiren	208	223	106	23	42	99	87	106	246	286	298	158
Bore	276	301	88	7	39	56	62	134	348	340	324	211
Merewa	249	305	97	19	32	49	48	147	307	322	297	204

Annex 9. Monthly distribution of *Amblyomma cohaerens* tick year 1999/2000 total tick count

Larva + nymph												
Site	September	October	November	December	January	February	March	April	May	June	July	August
JCA	101	89	42	10	18	45	75	99	115	118	91	87
Blida	33	21	9	3	12	11	28	31	51	45	38	34
Jiren	38	31	12	3	10	18	19	26	63	48	42	29
Bore	43	52	7	6	8	9	13	31	89	60	66	43
Merewa	51	48	6	2	6	8	16	35	72	78	41	46
Adult												
Site	September	October	November	December	January	February	March	April	May	June	July	August
JCA	105	111	104	12	16	22	48	79	82	122	119	92
Blida	44	41	25	5	10	7	9	17	37	51	53	31
Jiren	49	43	28	2	6	14	11	14	29	53	47	27
Bore	50	50	31	4	7	10	8	16	56	66	87	34
Merewa	70	47	24	3	7	8	4	7	31	86	86	36
Adult + Larva + Nymph												
Site	September	October	November	December	January	February	March	April	May	June	July	August
JCA	206	200	146	22	34	67	123	178	197	240	210	179
Blida	77	62	34	8	22	18	37	48	88	96	91	65
Jiren	87	74	40	5	16	32	30	40	92	101	89	56
Bore	93	102	38	10	15	19	21	47	145	126	153	77
Merewa	121	95	30	5	13	16	20	42	103	164	127	82