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THE MEDICAL SIGNIFICANCE OF TICKS

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ABSTRACT

Human Monocytic Ehrlichiosis (HME) is an emerging disease first described in 1987 and is transmitted by the bite of Amblyomma americanum. Over the past 10 years, the CDC has documented increasing ehrlichiosis case reports nationwide. Our study site is a golf-oriented retirement community located in the Cumberland Plateau of Tennessee. In 1993, four men at the study site had symptoms consistent with HME which prompted a CDC outbreak investigation and led community managers to mitigate ticks feeding on deer. The objectives of this study were to measure the efficacy of current tick mitigation attempts, to determine the level of infection and composition of tick-borne disease in the study area, and to assess which wildlife species are potentially acting as reservoirs for disease. Ticks were sampled in the community at eight sites of _4-poster‘ acaricide applicator utilization and at seven untreated sites. Close to the _4-poster‘ devices, larval, nymphal, and adult tick abundances were reduced by 90%, 68% and 49% respectively (larval $p< 0.001$, nymphal $p< 0.001$, adult $p=0.005$) relative to the untreated areas. We extracted DNA from A. americanum ticks collected at the treatment and non-treatment sites and tested for Ehrlichia spp. infections. Of 253 adult and nymphal A. americanum tested, we found 1.2% to be positive for Ehrlichia chaffeensis, 4.7% positive for Ehrlichia ewingii, and 1.6% positive for Panola Mountain Ehrlichia; in combination this prevalence is similar to that reported in other Ehrlichia-endemic areas of the eastern U.S.. We also performed blood meal analysis on DNA from A. americanum ticks and the results suggest

that the most significant reservoir hosts for Ehrlichia spp. are white-tailed deer, turkeys, grey squirrels, and Passeriformes.

INTRODUCTION

Ticks are parasitic arachnids that feed on the blood of mammals, birds, and reptiles. They are known to transmit a variety of diseases to humans, animals, and wildlife. Ticks are found in every part of the world and are most commonly found in wooded areas, grasslands, and shrubs.

Ticks are capable of transmitting a variety of diseases, including Lyme disease, Rocky Mountain spotted fever, tularemia, babesiosis, anaplasmosis, and many others. These diseases can have serious consequences for humans, such as fever, fatigue, joint pain, and, in some cases, even death.

The medical significance of ticks lies in their ability to transmit diseases. Lyme disease, for example, is the most commonly reported tick-borne illness in the United States, with over 30,000 cases reported to the Centers for Disease Control and Prevention (CDC) each year. It is caused by the bacterium Borrelia burgdorferi, which is transmitted to humans through the bite of an infected black-legged tick.

Rocky Mountain spotted fever is another tick-borne illness that can be serious if left untreated. It is caused by the bacterium Rickettsia rickettsii, which is transmitted to humans through the bite of an infected American dog tick, Rocky Mountain wood tick, or brown dog tick.

MEDICAL SIGNIFICANCE OF TICKS TYPES

There are several types of tick-borne diseases that are medically significant to humans, animals, and wildlife. These include:

1. Lyme disease: This is the most commonly reported tick-borne illness in the United States and is caused by the bacterium Borrelia burgdorferi. Symptoms of Lyme disease can include fever, headache, fatigue, and a characteristic rash that resembles a bull's eye. If left untreated, Lyme disease can lead to more serious symptoms such as joint pain, neurological problems, and heart problems.

2. Rocky Mountain spotted fever: This is a potentially fatal tick-borne disease caused by the bacterium Rickettsia rickettsii. Symptoms can include fever, headache, muscle

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aches, and a characteristic rash that often starts on the hands and feet and spreads to the trunk of the body.

3. Ehrlichiosis: This is a bacterial infection that can be transmitted by several types of ticks, including the lone star tick and the black-legged tick. Symptoms can include fever, headache, fatigue, and muscle aches.

4. Babesiosis: This is a parasitic infection that is transmitted by the black-legged tick. Symptoms can include fever, fatigue, and muscle aches, and in severe cases, it can lead to anemia and other complications.

5. Anaplasmosis: This is a bacterial infection that can be transmitted by several types of ticks, including the black-legged tick and the western black-legged tick. Symptoms can include fever, headache, muscle aches, and fatigue.

TICK TAXONOMY

Two special publications have appeared on tick taxonomy: Camicas, Harvy, Adam & Morel compiled a comprehensive list of the ticks of the world (Camicas et al. 1998) and Horak, Camicas & Keirans (2002) continued this endeavour by presenting a revised world list of names of valid tick species. According to this latter list, approximately 80% of the world's tick fauna are ixodid ticks (hard ticks) (683 species), and, with the exception of one species in the family Nuttalliellidae, the remainder are argasid ticks (soft ticks) (183 species). This list has formed the basis for an interactive database in access 2000, designated Tickbase, containing the total of 867 currently known tick species. The world's argasid tick fauna is divided into four genera, namely Argas, Carios, Ornithodoros and Otobius, whereas the world ixodid tick fauna consists of 241 species in the genus Ixodes and 442 species in the remaining genera. The most important genera of hard ticks are Amblyomma, Boophilus, Dermacentor, Haemaphysalis, Hyalomma, Ixodes and Rhipicephalus. Although it has been proposed by Horak et al. 2002, to place the five species of the genus Boophilus in the genus Rhipicephalus, to reflect their close phylogenetic relationship and evolution, this proposal has kept the name Boophilus in common usage as a subgenus (Barker and Murrell, 2002; Horak et al. 2002). To avoid confusion, we continue to treat Boophilus separately from Rhipicephalus since Boophilus ticks are among the best-known in the world. A detailed account of modern tick systematics is given in the chapter of this book by Barker & Murrell.

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IMPORTANT TICKS OF THE WORLD

Most ticks have a preference for feeding on certain groups of wild animals, with some even being quite host specific. Consequently, the number of species pertinent to domestic animals and/or humans is limited. As a matter of fact, relatively few species of ticks have successfully adapted to livestock or may feed on a human subject, and these have developed into efficient vectors of a range of pathogenic micro-organisms. Virtually all human tick-borne diseases are zoonoses.

IMPORTANCE OF TICKS

Ticks are important to human and veterinary medicine for a variety of reasons:

- as vectors of bacterial, protozoal, rickaettsial, spirochaetal and viral diseases of humans, domestic stock and companion animals.
- as ectoparasites with irritating bites causing extensive harm to their hosts due to blood loss, damage to the skin and anorexia leading to reduction in growth.
- as agents of 'tick paralysis' in man and animals, probably due to the secretion of toxic substances in their saliva.
- in exacerbating the lesions caused by Dermatophilosus congolensis (dermatophilosis) in cattle, goats and sheep; this is caused by immunosuppressive effects of the tick feeding.
- in predisposing their hosts to other arthropod infestations such as the screwworm fly, Cochliomyia hominovorax.

DAMAGES CAUSED BY TICKS AND THEIR CONTROL

Ticks comprise veterinary problem because they transmit diseases, produce paralysis or toxicosis, and cause physical damage to livestock. Ticks' species are grouped into three families, Argasidae or soft ticks, Ixodidae or hard ticks and Nuttalliellidae (Klompen et al., 1996). Ticks are very important to man and his domestic animals, and must be controlled if livestock production is to meet world needs for animal protein. Knowledge of the nature and habits of the tick and the disease agents it transmit helps in control.

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Losses and control

A complex of problems related to ticks and tick-borne diseases of cattle created a demand for methods to control ticks and reduce losses of cattle (George et al., 2004). Control of tick infestations and the transmission of tick-borne diseases remain a challenge for the cattle industry in tropical and subtropical areas of the world. Tick control is a priority for many countries in tropical and subtropical regions (Lodos et al., 2000). Losses due to tick infestations can be considerable. In Australia alone in 1974, losses due to cattle tick (Boophilus microplus) were estimated to be USD 62 million (Springell, 1983). Brazil loses around USD 2 billion per year (Grisi et al., 2002). Such losses can be cut considerably by adopting effective tick control measures. There are three major reasons for controlling ticks in domestic animals: disease transmission, tick paralysis or toxicosis, and tick-caused physical damage. The main weapon for controlling ticks at present is the use of chemical acaricides (Drummond, 1983). Ticks are responsible for severe economic losses both through direct effect of blood sucking and indirectly as vector of pathogens and toxins.

1. Direct effect

Feeding by large numbers of ticks causes reduction in live weight and anemia among domestic animals, while tick bites also reduce the quality of hides. Apart from irritation or anemia in case of heavy infestations, tick can cause severe dermatitis (FAO, 1998). These parasites generate direct effects in cattle in terms of milk production and reduce weight gain .

(1) Tick-bite paralysis

It is characterized by an acute ascending flaccid motor paralysis caused by the injection of a toxin by certain ticks while feeding. Examples are paralysis caused by the feeding of Dermacentor andersoni, sweating sickness caused by Hyalomma truncatum, Australian tick paralysis caused by Ixodes holocylus, and tick toxicosis caused by Rhipicephalus species (Drummond, 1983). Tick paralysis is most common in late winter and spring when the adult ticks are active, but it can occur at any time if the weather is warm and humid. Paralysis in cattle caused by Ixodes holocyclus and Dermacentor andersoni had also been reported by Doube and Kemp (1975) and Lysyk et al.(2005) respectively.

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(2) Physical damage

Ticks are attached to the body for a blood meal and may cause irritation and serious physical damages to livestock. Included are “tick worry”, irritation, unrest, and weight loss due to massive infestation of ticks; the direct injury to hides due to tick bites, loss of blood due to the feeding of ticks.

2. Vector of pathogens

Ticks can be carrier, of pathogens, which they transmit from host to host during blood sucking and cause a large variety of diseases (FAO, 1998). The major diseases include Babesiosis, Anaplasmosis, Theileriosis, and heart-water, East Coast fever; in addition, other diseases of lesser importance cause severe economic losses to the livestock industry (Drummond, 1983; Bram, 1983). The presence, dynamics and amount of parasite stock in ticks exert a major influence on the kinetics of transmission of tick-borne parasitic diseases (Morel, 1980). Generally the ticks become infested with the causative organisms of diseases while they are feeding on infected animals. Then the organism may be transmitted from stage to stage in the tick (an example is Theileria parva transmitted by Rhipicephalus appendiculatus), or from the female tick through the egg to the larvae—an increase of several thousand times in vector potential (an example is Babesia equi transmitted by Anocentor nitens). When the next stage or generation subsequently feeds on another animal, the organism is transmitted to that animal if it is susceptible to the disease (Drummond, 1983). Tick born diseases generally affect the blood and/or lymphatic system (FAO, 1998). Tick fever organisms, like Anaplasma marginale, are significant causes of cattle morbidity in Australia, USA, China and other countries (CRC-VT, 2001). Cattle tick B. microplus, economically impact cattle production by transmitting pathogens that cause Babesiosis B. bovis and B. bigemina) and Anaplasmosis (A. marginale)

Chemical control of ticks

There are several methods being applied for controlling ticks and tick-borne diseases. The main weapon for the control of ticks at present is the use of chemical acaricides. Acaricides used to control ticks on livestock or in the environment are applied in such a manner that the ticks are killed, but will not harm livestock or applicators, the tissues of treated animals will not contain chemical residues, and the environment will not be adversely affected (Drummond, 1983). The conventional control methods include the use of chemical acaricides with partially successful

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results but this treatment has certain implicit drawbacks, such as the presence of residues in the milk and meat and the development of chemical resistant tick strains (Willadsen and Kemp, 1988; Nolan, 1990). The use of acaricides has disadvantages, such as the selection of resistant tick populations and harmful effects on the animals, human beings and the environment (García-García et al., 2000). The development of new acaricides is a long and expensive process, which reinforces the need for alternative approaches to control tick infestations (Graf et al., 2004). Certain herbal mixtures with 70% efficacy for tick control have also been reported by Regassa (2000).

1. Acaricides

Control of tick infestation through the use of acaricides is one of the methods that can be used to reduce the tick-borne diseases (Spickett and Fivaz, 1992). A wide range of acaricides, including arsenical, chlorinated hydrocarbons, organophosphates, carbamates and synthetic pyrethroids are being used for controlling ticks on livestock. The performance of an acaricide in the control of ticks depends not only on the activity of a product, but on the quality and quantity of active ingredient deposited on cattle or delivered internally (George, 2000).

2. Arsenic

Use of arsenic was the first effective method for controlling ticks and tick-borne diseases, and was used in many parts of the world before resistance to the chemical became a problem (George, 2000). It was first used for tick control in 1893 in South Africa (Bekker, 1960) that is inexpensive, stable, and water soluble, and there is an accurate vat-side test (Drummond, 1983). Arsenic was the first acaricides to be widely used which is cheapest and most effective agent. Mostly it is used in the form of water soluble compounds like sodium arsenite. Usually As_2O_3 have been used for many years in dipping vats to control ticks, especially ticks of the genus Boophilus. Arsenic dips were used successfully to eradicate Boophilus ticks from the southern United States. Unfortunately, arsenic has a very short residual effectiveness (less than one to two days), and in most areas of the world Boophilus ticks have become resistant to arsenic (Drummond, 1983).

3. Chlorinated hydrocarbons

These are synthetic acaricides. Resistance to arsenicals was developed in many species of ticks (Matthewson and Baker, 1975; Angus, 1996) and it was replaced by chlorinated hydrocarbons

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(Graham and Hourrigan, 1977). Chlorinated hydrocarbon acaricides are very persistent and have been used extensively throughout the world for controlling ticks. Of particular interest are benzene hexachloride toxaophene (Drummond, 1983). Their mode of action is by interfering with nerve conduction of ticks (Solomon, 1983). Because of their high toxicity and long lifespan, these compounds have mostly been withdrawn from the market (Spickett, 1998).

4. Organophosphorous compounds

Organophosphates were introduced around 1950, as a replacement for the chlorinated hydrocarbons to which significant resistance had occurred (Shanahan and Hart, 1966). These are esters of phosphoric acid and have a wide range of activities against ticks at very low concentration in companion and livestock animals. However, their residual effectiveness is usually shorter than that of chlorinated hydrocarbons, and the risk of causing acute toxicity in livestock is greater (Drummond, 1983). Resistance in ticks was first recognized in 1963 and several tick species are now known to be resistant to organophosphorous acaricides (Wharton, 1967).

5. Carbamates

These are esters of carbamic acids and closely resemble the organophosphates (Spickett, 1998). They are a little more toxic than the organophosphates for mammals and are much more expensive.

Application of chemicals

Various methods including dipping, spraying, ear tagging or pour on, have been used to apply chemicals to protect livestock against ticks. Direct application of acaricides to animals is the most popular method of controlling ticks on livestock (Drummond, 1983). Applications of acaricide to tick-infested cattle via dipping or sprayer can be equally effective under ideal conditions with proper handling of equipments without injuring animals and subsequent dilution of a product (George, 2000).

1. Dipping

In this method, animals are immersed in a dipping tub containing solution of chemicals. By 1893 in Australia, Africa, and the United States the use of “dipping-vats” to immerse tick-infested cattle in a variety of chemical agents was a component of the effort to control the ticks

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and tick-borne diseases affecting cattle (Mohler, 1906; Matthewson and Baker, 1975). A variety of tickicides including cottonseed oil, fish oil, crude petroleum, kerosene, creosote, tobacco extract, soap, and a combination of sulphur and kerosene were among the hundreds of possible acaricides tested for dipping (Mohler, 1906; Angus, 1996). Infested cattle should be dipped in the organophosphate acaricide coumaphos (0.3% active ingredient) (Bram et al., 2002). In general, dipping vats provide a highly effective method of treating animals with acaricides for tick control. However, their immobility, high initial cost of construction, and the cost of the acaricides may make vats impractical for many small ranching operations. Also, dipping vats must be managed carefully so that the dips are maintained at the proper concentration and the cattle are dipped properly (Drummond, 1983).

2. Spray

The application of fluid acaricides to an animal by means of a spray has many advantages and has been successfully practiced for controlling ticks on most of the animals (Barnett, 1961). Spraying equipment is highly portable, and only small amounts of acaricides need to be mixed for a single application. However, spraying is generally less efficient in controlling ticks than immersion in a dipping vat because of problems associated with applying the acaricides thoroughly on all parts of the animal body (Drummond, 1983).

3. Spot treatment or hand dressing

There are predilections sites for certain tick species on part of the body which are not effectively treated by spray or dips. The inner parts of the ear, under part of the tail, the tail brush and the areas between the teats and the legs in cattle with large udder, are especially liable to escape treatment. Acaricides may be applied to these sites by hand is termed as hand dressing (Barnett, 1961) or spot treatment. The application of insecticides with aerosols and in oils, smears, and dusts by hand to limited body areas is time-consuming and laborious, but in certain instances it may be more effective and economical (in terms of cost of acaricide) than treating the entire animal (Drummond, 1983).

4. Some other applications

Some other methods of applying acaricides are ear tags, neck bands, tail bands and pour-one, particularly for the pyrethroids with long residual activity. A mechanical applicator was also developed (Duncan, 1991). In Kenya, an intraruminal ivermectin slow-release device provided

90 d protection against tick damage (Tatchell, 1992). Tick repellents used on livestock are limited (Mwase et al., 1990). Ivermectin has been delivered orally in the case of Boophilus annulatus on cattle by Millar et al.(2001) as a single or double ruminal bolus as daily capsules to B. miroplus infested cattle. The control levels against standard engorging female ticks reached 99%. Despite this, the level of control of ticks on pastures grazed by treated cattle was insufficient to prevent cattle from becoming infested when grazed there later on. Abdel-Shafy and Zayed (2002) examined the acaricidal effect of plant extract of neem seed oil (Azadirachta indica) on egg, immature and adult stages of Hyalomma anatolicum excavatum. This short communication on the potential use of azadirachtin for tick control is an extension from the large volume of literature on this material for control of crop pests and vectors of medical pathogens. Azadirachtin was applied at concentrations of 1.6% through to 12.8% in water and applied to ticks in vitro for 1 min. The ticks were examined up to 15 d post treatment for mortality and reduced viability. Abdel-Shafy and Zayed (2002) concluded that Neem can be used for tick control at economic concentrations of 1.6% to 3.2%. The work will need to be enlarged to test control of feeding ticks on cattle and possibly control of ticks by spraying the moulting and resting site of ticks in cattle pens.

OBJECTIVES

1. Identify the different types of tick-borne diseases and their symptoms: This is important to help individuals recognize the signs of tick-borne illnesses and seek medical attention as soon as possible.

2. Understand the transmission of tick-borne diseases: By understanding how tick-borne diseases are transmitted, individuals can take steps to prevent tick bites and reduce their risk of infection.

REVIEW OF LITERATURE

Zahid Iqbal Rajput (2006) The medical and economic importance of ticks has long been recognized due to their ability to transmit diseases to humans and animals. Ticks cause great economic losses to livestock, and adversely affect livestock hosts in several ways. Loss of blood is a direct effect of ticks acting as potential vector for haemo-protozoa and helminth parasites. Blood sucking by large numbers of ticks causes reduction in live weight and anemia among domestic animals, while their bites also reduce the quality of hides. However, major losses caused by ticks are due to their ability to transmit protozoan, rickettsial and viral diseases of livestock, which are of great economic importance world-wide. There are quite a few methods for controlling ticks, but every method has certain shortcomings. The present review is focused on ticks importance and their control.

F. JONGEJAN (2005) Ticks and tick-borne diseases affect animal and human health worldwide and are the cause of significant economic losses. Approximately 10% of the currently known 867 tick species act as vectors of a broad range of pathogens of domestic animals and humans and are also responsible for damage directly due to their feeding behaviour. The most important tick species and the effects they cause are listed. The impact on the global economy is considered to be high and although some estimates are given, there is a lack of reliable data. The impact of ticks and tick-borne diseases on animal production and public health and their control are discussed.

RAJPUT Zahid Iqbal (2006) The medical and economic importance of ticks has long been recognized due to their ability to transmit diseases to humans and animals. Ticks cause great economic losses to livestock, and adversely affect livestock hosts in several ways. Loss of blood is a direct effect of ticks acting as potential vector for haemo-protozoa and helminth parasites. Blood sucking by large numbers of ticks causes reduction in live weight and anemia among domestic animals, while their bites also reduce the quality of hides. However, major losses caused by ticks are due to their ability to transmit protozoan, rickettsial and viral diseases of livestock, which are of great economic importance world-wide. There are quite a few methods for controlling ticks, but every method has certain shortcomings. The present review is focused on ticks importance and their control.

Jamyang Namgyal (2021) Livestock farming plays an important role in supporting the livelihood of resource-poor subsistence farmers in Bhutan. However, ticks and tick-borne diseases (TBDs) are one of the major constraints to livestock farming due to their negative effect on health and production. To date, no study has been conducted in Bhutan to assess farmers' knowledge, attitude, and practices (KAP) about ticks and TBDs in cattle, although such information is essential in ensuring the development and adoption of effective prevention and control measures. Therefore, a KAP survey was conducted among 246 cattle owners in the Samkhar sub-district of eastern Bhutan in June 2019, using a structured questionnaire. Based on our scoring criteria, 52% [95%CI: 45.5–58.4] had adequate knowledge about ticks as potential vectors of diseases. Logistic regression analysis showed that the individuals who practiced a stall-feeding system of cattle rearing were 2.8 times [OR = 2.8 (95%CI: 1.66–4.78)] more likely to have adequate knowledge than others. Sixty-eight percent [95%CI: 62.5–74.4] had a favorable attitude toward tick prevention and control programs. Men were 1.95 times [OR = 1.95 (95%CI: 1.09–3.55)] more likely to have a favorable attitude than women, and the individuals who practiced a stall-feeding system were 2.59 times [OR = 2.59 95%CI: 1.45–4.78)] more likely to have a favorable attitude than others, after adjusting for the effect of other variables in the model.

Heather Stanley (2016) Tick-borne disease is found all over the world, and interest in disease surveillance for tick-borne illnesses has increased, partly because some of the illnesses are becoming more common. Tick collection is an integral and necessary part of disease surveillance, and knowledge of the ticks' habitats, life cycles, and different collection methods increases the chance of their capture. Beginning in March of 2015, ticks were collected using CO2 traps from Candlers Mountain in central Virginia. The tapes used in the traps were experimentally tested using a force transducer to create a trap that would capture the greatest number of ticks. From March through June, 62 deer and lone star ticks were collected using this method. The lab experiments suggested that duct tape and colored lab tape would be the best choice for a CO2 trap. The researchers believe that better education about tick species, habitats, and the potential risk of tick-borne diseases will help people in the Lynchburg area and around the world protect both themselves and their pets.

Mpho Tawana (2022) Ticks are hematophagous ectoparasites that are capable of infesting a wide range of mammals, including domestic animals, ruminants, wildlife, and humans across the world, and they transmit disease-causing pathogens. Numerous individual epidemiological studies have been conducted on the distribution and prevalence of ticks and tick-borne diseases (TBDs) in the Southern African Developing Community (SADC) region, but no effort has been undertaken to synchronize findings, which would be helpful in the implementation of consolidated tick control measures. With the aim of generating consolidated pooled prevalence estimates of ticks and TBDs in the SADC region, we performed a systematic review and meta-analysis of published articles using the PRISMA 2020 guidelines. A deep search was performed on five electronic databases, namely, PubMed, ScienceDirect, Google Scholar, AJOL, and Springer Link. Of the 347 articles identified, only 61 of the articles were eligible for inclusion. In total, 18,355 tick specimens were collected, belonging to the genera Amblyomma, Haemaphysalis, Hyalomma, and Rhipicephalus (including Boophilus) across

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several countries, including South Africa (n = 8), Tanzania (n = 3), Zambia (n = 2), Zimbabwe (n = 2), Madagascar (n = 2), Angola (n = 2), Mozambique (n = 1), and Comoros (n = 1). The overall pooled prevalence estimate (PPE) of TBPs in livestock was 52.2%, with the highest PPE in cattle [51.2%], followed by sheep [45.4%], and goats [29.9%]. For bacteria-like and rickettsial TBPs, Anaplasma marginale had the highest PPE of 45.9%, followed by A. centrale [14.7%], A. phagocytophilum [2.52%], and A. bovis [0.88%], whilst Ehrlichia ruminantium had a PPE of 4.2%. For piroplasmids, Babesia bigemina and B. bovis had PPEs of 20.8% and 20.3%, respectively. Theileria velifera had the highest PPE of 43.0%, followed by T. mutans [29.1%], T. parva [25.0%], and other Theileria spp. [14.06%]. Findings from this study suggest the need for a consolidated scientific approach in the investigation of ticks, TBPs, and TBDs in the whole SADC region, as most of the TBDs are transboundary and require a regional control strategy.

RESEARCH METHODOLOGY

Our study site is a golf-oriented retirement community of roughly 6,000 residents which encompasses 5,260 ha. of heavily wooded land on the Cumberland Plateau in Tennessee. The community‘s attractions consist of championship golf courses, tennis courts, swimming, lakes for boating and fishing, horseback riding, sightseeing, trails, and shopping. The border along the north end of the community is adjacent to a 32,370 ha wildlife management area and as a result, white-tailed deer and other wildlife are common throughout the community. The northern part of the community has a higher tick abundance and disease risk, presumably because of this shared border (R.Gerhardt, pers. comm., October 2010). The fragmentation of the community as a result of interspersed fairways, woodlands, and residences provides ample wildlife habitat, and therefore the opportunity for tick populations to thrive.

Community Services Management at the retirement community selected eight sites for deployment of 4-poster‘ acaricide applicators based on previous treatment locations, proximity to inhabited areas, and areas of known high tick abundance. Four 4-posters‘ are located in the northern half of the community and four are located in the southern half. 4-poster‘ usage regulations prohibit use of these devices within 100 yards of any residence or area where unsupervised children may be present, leading to difficulty of utilization within a residential community such as our study site. This was the first year of treatment using 4-poster‘ acaricide applicators at transects 1, 7, 8, and 9 whereas _4-poster‘ treatment has been used for at least two years at transects 4, 5, 12, and 13. Mitigation techniques had never been attempted at the six nontreatment sites (2, 3, 6, 10, 11, and 14)

DATA ANALYSIS

Results and Discussion

The great majority of collected ticks (99.43%) were A. americanum followed by Dermacentor variabilis (0.47%) and Ixodes scapularis (0.10%). We excluded D. variabilis and I. scapularis from further analysis as their low abundance suggests they present minimal risk to humans in this community. In contrast, we found the A. americanum population to be widespread throughout the community, with all life stages of A. americanum ticks collected fromall 14 sampling sites (Fig. 4.1). Our data confirmed the perception of community managers that A. americanum numbers are highest in the northern part of the community. Sites in the northern half had an estimated 91% higher nymphal A. americanum population density and 35% higher adult A. americanum population density than sites in the southern half of the community (Fig.2.1; $p<0.001$ for both comparisons). During the period of peak larval questing (August - October) the average abundance of larvae was 2.4 times higher on the northern transects than onthe southern transects ($p=0.0011$). A strong seasonal effect was detected with adults peaking slightly earlier in the year than nymphs. The observed seasonality is the same in the treatment and non-treatment areas, although there are fewer ticks overall at the treatment sites than at the non-treatment sites (Fig. 4.2).

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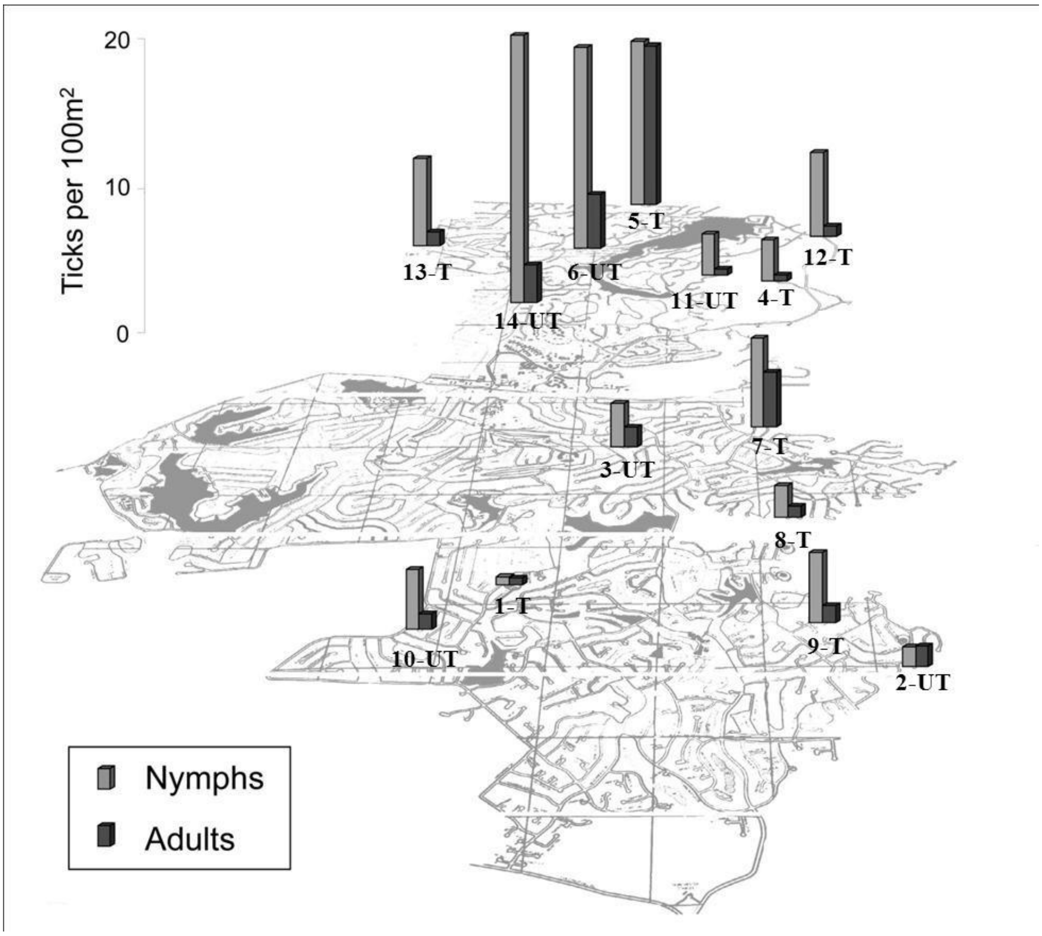

Mean counts of nymphal and adult A. americanum at 14 sites within the studyarea. Adult means are for the period March 24 – June 16, 2009; nymphal means are for the period May 11 – July 27, 2009. (T=treatment site, UT=untreated site)

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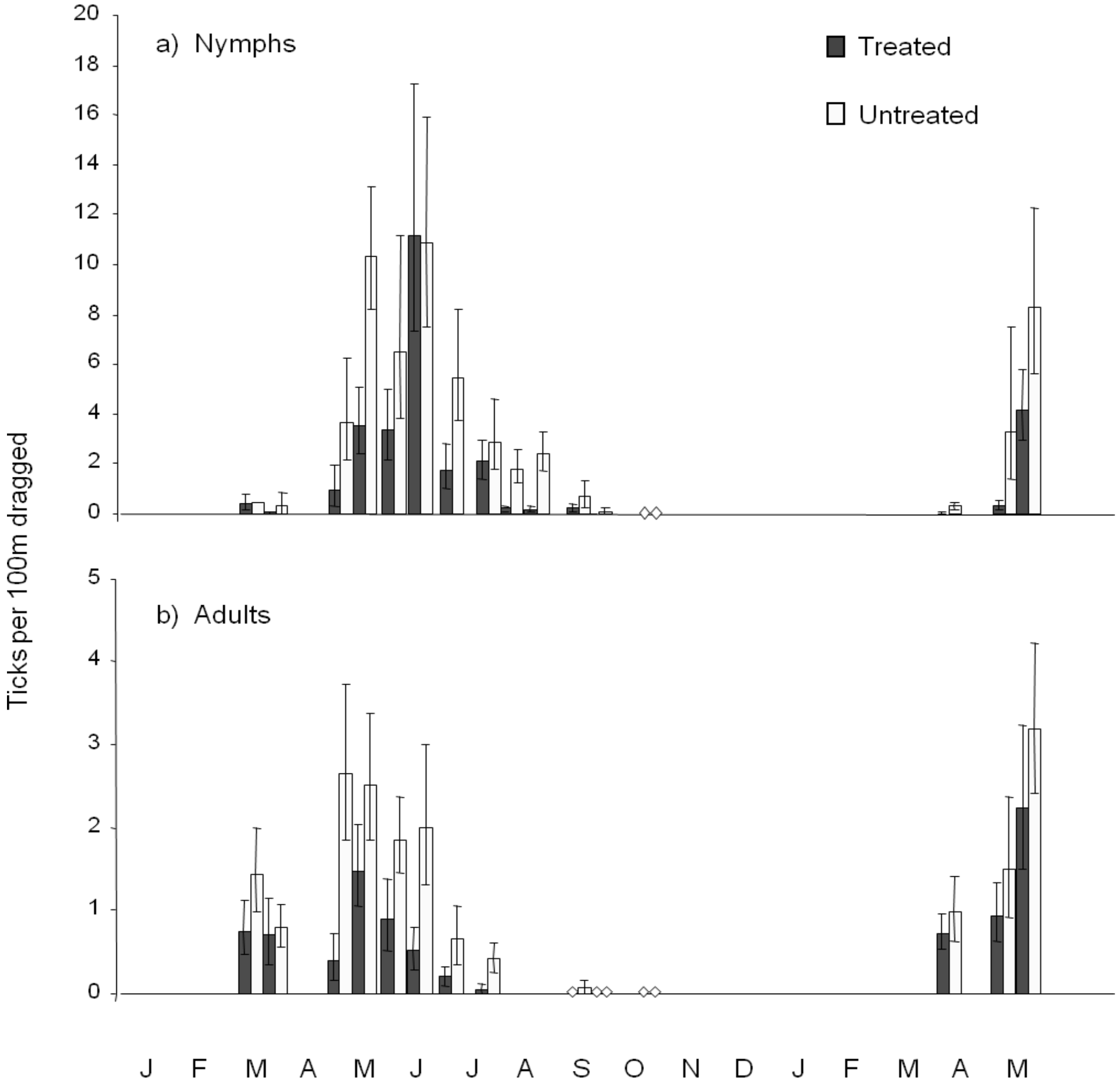

Seasonal variation in nymphal and adult tick abundance. Nymphs peak slightlybefore adult ticks and tick abundance at treated sites is less than at untreated sites in almost every month.

We observed a proximity effect of the ‗4-poster' treatment on tick populations, with the treatment effect becoming non-significant for nymphs and adults at >300m from the ‗4-poster'. Therefore the diameter of measurable effect around the ‗4-poster' acaricide applicators is 600m (Figure 4.3). Treatment effects were more evident for nymphs than for adults, with an observed68% reduction of nymphs and 49% reduction of adults within 40m^2 of the ‗4-poster' devices (nymphal p<0.001, adult p=0.005). A 90.1% percent reduction of larval A. americanum ticks was detected at treatment transects and is highly significantly different from non-treatment sites for the entire sampled distance (Fig. 4.4). These treatment effects exist at sites in the first year oftreatment as well as sites in the second year of treatment, and the difference in effect for the twotreatment classes is not significant. Time constraints and

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community set-up hindered our ability to test farther than the original 400m transect distance, therefore the extent of _4-poster' device distance effect on A. americanum larvae is unclear.

4.1 Results and Discussion

Ticks from our retirement community field site were infected with Ehrlichia spp. at similar values found in other Ehrlichia endemic areas. Of 232 adult and nymphal A. americanumtested from our study site, we found two positive for E. chaffeensis (0.86%), fourteen positive for E. ewingii (6.03%), and four positive for Panola Mountain Ehrlichia (1.72%). Of the positives, there were one adult male and one adult female positive for E. chaffeensis, nine adult males, fouradult females, and one nymph positive for E. ewingii, and two adult males and two nymphs positive for Panola Mountain Ehrlichia. The gltA sequences for Panola Mountain were identical to the reported PME sequence reported by Loftis et al (2008) (GenBank: DQ363995). Of 82 ticks tested from HHSP, two were positive for E. chaffeensis (2.4%), one was positive for E. ewingii(1.2%), and two were positive for Panola Mountain Ehrlichia (2.4%). These results were not significantly different, although a higher prevalence of E. ewingii was found in our primary sitethan at HHSP (Fig. 1).

ist of oligonucleotide sequences of primers and probes used to analyze bloodmeal source for Amblyomma americanum in thenited States.

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Oligo primer/probe Name	Nucleotide sequence	Target organism
Primers		
N.A. 12S-6F	CTR GGA TTA GAT ACC CYA CTA TG	Vertebrates
N.A. B-12S-9R	5' biotin-ATT AYA GRA CAG GCT CCT CTA	Vertebrates
Probes		
N. Green Anole	5'-CAG AAA AGC CTA AAA CTC AA	*Anolis carolinensis*
N. Fence Lizard	5'-CAC TAA AAT ATC CGC CAG AAA AC	*Sceloporus undulatus*
E. Six-lined Racerunner	5'-CAC CCC TAC CTA GAG GAG	*Cnemidophorus sexlineatus*
Broadhead, Five-lined skink	5'-GCC AGA GAA CTA CAA GTG A	*Eumeces*
Little brown skink	5'-CAG AGA ACT ACA AGC GAA A	*Scincella lateralis*
All Turtle	5'-ACA AAA ATA TCC GCC AGA GA	*Testudines*
All Birds except Owl	5'-ACG CTT AAA ACT CTA AGG AC	*Aves*
Owls	5'-TTA AAA CCC TAA GGA CTT G	*Strigiformes*
Turkey	5'-CTT GAT ACT AAT ATA CTC ACG TAT CC	*Maleagris gallopavo*
Vulture	5'-CTC ACC AAA GCA TCC G	*Cathartidae*
Quail and Bobwhite	5'-CTA AAT CCA GAT ACC CCC AAT	*Colinus virginianus*
Passerine bird	5-TGC TTA CAC CTA CTA AAG CAT CC	*Passeriformes*
Cat, Thrasher, Mocking..	5'-TTG ATA CTC GAT ATT ACC TGA GT	*Mimidae*
Robin, Thrushes	5'-TGA TGC TCG ATA TTA CCT GA	*Turdidae*
Mourning Dove, Pigeon	5'-TCT AGA TGC TTA TGT TAC TAA AGC AT	*Columbidae*
N. American small rodent	5'-GAC TTG GCG GTA CTT TAT ATC	*Rodentia*
Virginia Opossum	5'-TAGTAATAAACTAAAATAATTTAACAAAC	*Didelphis virginiana*
American short-tailed shrew	5'-GGT AAT TTA ATT AAC AAA ACT ACT CG	*Blarina*
Long-tailed shrew	5'-CTA ACA AAA ATA CCC GCC AGA	*Sorex*
Moles	5'-AAC TAA GAC AAT CCA ACT AAC AAG	*Talpidae*
Deer mouse	5'-GGC CAT CGC TTA AAA CTC	*Peromyscus maniculatus*
White-footed mouse	5'-TAC TGG CTA CCG CTT AAA ACT	*Peromyscus leucopus*
Cotton mouse	5'-CCC TAA ACC TCA AAG ATT AAA TA	*Peromyscus gossypinus*
House mouse	5'-TGC TTA GCC ATA AAC CTA AAT	*Mus musculus*
Cotton rat	5'-TAG CCC TAA ACC ACA ATA ACT TA	*Sigmodon hispidus*
Wood rat	5'-CCTAAACCCTAATAATTCAATAACAAAAT	*Neotoma floridana*
Rat	5'-CTT AGC CCT AAA CCT TAA TAA TTA	*Rattus*
Vole	5'-CAA AAA TAT TTG CCT GAG AAC	*Microtus*
Chipmunk	5'-GCT TAG CCT TAA ACA CAA ATA C	*Tamias striatus*
Squirrel	5'-AGA GAA CTA CTA GCC ACT GCT	*Sciurus carolinensis*
Woodchuck	5'-CAT AAA CAT TCA ACA AAC AAG AA	*Marmota monax*
Cottontail	5'-GCC CTA AAC TTA AAT AAT TCC ATA AC	*Sylvilagus floridanus*
Striped Skunk	5'-GCC ATA AAC ACA GAC AAT TAA TAT	*Mephitis mephitis*
Raccoon	5'-ACG TAA CAA AAT TAT TTG CCA	*Procyon lotor*
Grey Fox	5'-AGT TCT ATA AAA CAA AAT AGT TCG C	*Urocyon cinereoargenteus*
Red Fox	5'-CTA TAA CAA AAC AAT TCG CC	*Vulpes vulpes*
Dog, Coyote	5'-CCC TAA ACA TAG ATA ATT TTA CAA CAA	*Canis*
Cats	5'-CAA AAC TAT CCG CCA GAG AA	*Felidae*
Deer	5'-AGT ACT ACC GGC AAT AGC TTA	*Odocoileus virginianus*
Pig	5'-TAC TAC TCG CAA CTG CCT	*Sus scrofa*
Cattle	5'-CCT AAA CAC AGA TAA TTA CAT AAA C	*Bos primigenius*
Horse	5'-CTA AAA TAG CTT ACC ACA ACA AA	*Equus ferus caballus*
Human	5'-AAA TCA ACA AAA CTG CTC GC	*Homo sapien*

Figure 4. 1 Comparison of Ehrlichia spp. infection prevalence in ticks from our retirement community study area and from Henry Horton State Park. Comparisons are for all Ehrlichia species combined, E. chaffeensis alone, E. ewingii alone, and Panola Mountain Ehrlichia alone. NS = not statistically significant; no significant differences were seen between the study area and the comparison site for any of the tested Ehrlichia species.

One reason for the lower observed detection of deer and turkeys as bloodmeal hosts at the primary study site is that community managers have been utilizing _4-poster' acaricide applicators to kill ticks feeding on deer in an attempt reduce the tick and tick-bornedisease risk to residents in the area. Trail cameras have documented turkeys feeding from ‗4- poster‘ devices as well, although they do not appear to be treated by the devices.

However, despite treatment efforts in this community, ticks feeding on deer still have the highest observed-to-expected ratio of Ehrlichia spp. infection of the top detected wildlife bloodmeal sources. The proportion of ticks feeding on feral pigs is also much higher in the retirement community than in the comparison site, likely due to the growing population of hogs found within the community. However, of ticks that fed on feral pigs, none tested positive for Ehrlichia species.

CONCLUSION

There are several benefits of the use of ‗4-poster‘ acaricide applicators to manage ticks and tick-borne disease. In just one year, it is possible to have an approximately 90% reduction of larval ticks at treatment sites. With additional treatment years, significant reductions of nymphaland adult life stages are also possible. Self-treatment of wildlife species is a simple way to manage ticks without having to handle and treat wildlife species or perform extensive acaricide applications that can result in non-target effects. However, this type of treatment is best used in a small area or at a site that does not have a high density of non-target wildlife species. In our large retirement community study site utilization of ‗4-poster‘ acaricide applicators as a sole method for managing ticks cannot efficiently reduce the numbers of ticks or the risk of tick- borne disease to community residents. Regulations on placement of ‗4-poster‘ devices in proximity to houses and areas where children may be present greatly limit the area in a community where acaricide applicators can be used. Resident concerns about deer-vehicle collisions due to deer being baited to particular areas of the community lead to additional limits for device placement. Even if community managers were able to afford the cost of buying and maintaining enough ‗4-poster‘ acaricide applicators for an area of this size, it is likely that they would be unable to evenly distribute them throughout the community while also maintaining adequate distance from residences and main roads.

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