MAKERERE UNIVERSITY

PREVALENCE AND RISK FACTORS OF TICKS INFESTING DOGS AND TICK CONTROL PRACTICES AMONG DOG OWNERS IN WAKISO, UGANDA

BY

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BVM V

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DECLARATION AND APPROVAL

I, **Rogers Byarugaba**, hereby declare that this report is my original work and to the best of my knowledge, it has not been presented to any institution as a requirement for total or partial reward of any academic award, publication or other use. Where the works of other people have been quoted, appropriate citations and references have been provided.

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DEDICATION

This work is dedicated to my family for their unwavering support in my academic journey.

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LIST OF ACRONYMS AND ABBREVIATIONS

AFSCAN	African Small Companion Animal Network
DDT	Dichlorodiphenyltrichloroethane
et al	And others
GABA	Gamma-aminobutyric acid
Glu-Cl	Glutamate gated chloride channels
GST	Glutathione S transferase
H. leachi	*Haemaphysalis leachi*
MAAIF	Ministry of Agriculture, Animal Industries, and Fisheries
MLs	Macrocyclic lactones
OPs	Organophosphates
PCR	Polymerase Chain Reaction
Rh. Sanguineus	*Rhipicephalus sanguineus*
RTC	Research Center for Tropical Diseases and Vector Control laboratory
SPs	Synthetic pyrethroids
TBDs	Tick-borne diseases
WSAVA	World Small Animal Veterinary Association

OPERATIONAL DEFINITIONS

Risk factors	Any attribute, characteristic, practice, or exposure that is statistically associated with a higher likelihood of finding ticks on dogs.
Tick Infestation	The presence of one or more ticks attached to or actively crawling on the body of a domestic dog.

ABSTRACT

Ticks are among the most important ectoparasites of dogs, serving as vectors of several pathogens of veterinary and zoonotic importance. Despite their impact, information on tick species infesting dogs and control practices among dog owners in Uganda remains limited. This study investigated the common tick species infesting dogs, tick control practices among dog owners and risk factors associated with tick infestation, in Wakiso - Uganda. A cross-sectional study design was employed involving 153 dog owners and 69 dogs that were found with ticks at the time of data collection. Adult ticks collected from the infested dogs were identified morphologically, while an online questionnaire was administered to dog owners to capture demographic data, dog management practices, and tick control methods. Logistic regression analysis was used to assess factors associated with tick infestation. A total of 310 adult ticks were collected from 69 infested dogs. *Rhipicephalus sanguineus* was the dominant species (99.68%), while *Haemaphysalis leachi* was rarely detected (0.32%). Topical acaricides and shampoos were the most commonly reported tick control methods (41.2%), although 39.9% of owners did not practice any control. Dogs interacting with other animals (OR = 2.4, 95% CI = 1.0-5.9, p = 0.046) and when does the dog owner know that it's time to control ticks (OR = 0.4, 95% CI = 0.2-0.7, p = 0.005) were the major risk factors associated with tick infestation. Use of unregistered acaricides and shampoos (6.12%), including afoxolaner and Castro medicated dog shampoo, was also reported, raising concerns about safety and resistance. The study concludes that *R. sanguineus* is the predominant tick species infesting dogs in Wakiso - Uganda, and that dog owners' practices play a critical role in infestation levels and tick control practice effectiveness. Strengthening veterinary extension service, educating dog owners on responsible dog ownership and improving regulation of acaricides are essential for sustainable management. These findings provide baseline information for guiding veterinary practice, and animal health interventions aimed at reducing the burden of ticks and tick-borne diseases in dogs in Wakiso - Uganda.

CHAPTER ONE: INTRODUCTION

1.1 Background

Ticks are hematophagous arthropods with a global geographical distribution, especially in tropical and subtropical regions. They parasitize a wide range of terrestrial and semi-terrestrial vertebrates, including dogs (Obaid et al., 2022). They are significant vectors of various pathogens that can cause severe diseases in both animals and humans. Tick-borne diseases, such as ehrlichiosis and babesiosis, are endemic in many parts of sub-Saharan Africa, including Uganda. In Uganda, ticks are prevalent, and their associated diseases pose a significant threat to public health and animal welfare (Proboste et al., 2015).

The most prevalent genera of ticks that infest dogs include; *Rhipicephalus*, *Amblyomma, Haemaphysalis*, and, to a lesser extent, *Ixodes* and *Hyalomma*. Among these, *Rhipicephalus sanguineus* is the most widespread in tropical and subtropical areas. Other notable species include *Rhipicephalus simus*, *Amblyomma variegatum*, *Haemaphysalis leachi*, and *Hyalomma truncatum* (Jongejan & Uilenberg, 2004; Walker et al., 2003). Based on the standardized multi-country surveillance study conducted by the African Small Companion Animal Network (AFSCAN), as part of the WSAVA Foundation, in 2021, it was found out that there was no consistent difference between East and West Africa in terms of diversity and number of tick species. A higher diversity of ticks was reported in rural habitats than in urban habitats, however much the highest diversity was recorded in an urban Uganda setting (Heylen et al., 2021).

Entebbe and Busiro South areas located within Wakiso, Uganda are the getaway to Uganda with the former housing the international airport for Uganda and a wildlife conservation area. The peri-urban areas, where agricultural activities are more prevalent, provide an ideal interface between rural and urban ecosystems. Urbanization, in particular, has been linked to changes in host-tick interactions, with peri-urban areas acting as transition zones where tick populations are sustained (Proboste et al., 2015). Dog travel or importation, has been implicated in influencing tick populations across the globe with recent reports pointing at the introduction of *Haemaphysalis longicornis* into the United States of America (Buczek & Buczek, 2021; Hayden, J. E.;Brambila, 2015) The study area being the first stop over for international travelers moving with their dogs poses a significant threat for the introduction of non-native tick species and their associated pathogens.

Effective control of ticks in dogs requires an integrated approach. Chemical control remains the most widely used method, with acaricides like fipronil, amitraz, and permethrin being applied as spot-on treatments, sprays, or collars (White & Gaff, 2018).The efficacy of these chemicals can be compromised by several factors, including environmental influences, incorrect application practices, and overuse. This situation amplifies the risk of acaricide resistance as ticks are continuously exposed to sub-lethal doses of these chemicals. Additionally, peri-urban areas often face challenges in access to veterinary services, leading to inconsistent use of acaricides and improper tick control measures (George et al., 2004).

Other strategies used for control of ticks include; biological control options, such as the use of natural predators like ants and fungal pathogens such as *Metarhizium anisopliae*. Environmental management is another key strategy, involving the regular cleaning of dog habitats and managing vegetation to reduce tick habitats. Additionally, vaccination against tick-borne diseases, though still in the experimental stage, holds promise for reducing disease transmission (Jongejan & Uilenberg, 2004; Spickett et al., 2011). Lastly, Integrated Tick Management (ITM) combines multiple strategies, such as chemical, biological, and environmental control methods, to reduce tick populations sustainably and mitigate the risk of resistance development (Walker et al., 2003). By understanding the common tick species infesting dogs, tick control practices among dog owners and their associated risk factors, this study contributes to surveillance of ticks infesting dogs in Wakiso, but also informs veterinary interventions.

1.2 Statement of the problem

Matthysse & Colbo characterized the Ixodid ticks of Uganda in (1987) and later on Walker et al .characterized the tick species of domestic animals in Africa including dogs in (2003). Since then, little has been done in the area of tick species identification and documentation in dogs in Uganda. Ticks however are becoming a significant health concern for dogs in many areas of the world as they vector parasites that transmit diseases to dogs; even in regions where they were traditionally not considered a major problem (Proboste et al., 2015). And with the increasing number of people traveling with their pets globally, there is a risk for introduction of non-native tick species into

Uganda. Research has shown that the prevalence of tick-borne diseases in Uganda's canine population is significant, with high infection rates reported in rural and urban settings (Proboste et al., 2015). These diseases not only pose a threat to canine health but also have implications for human health, as dogs potentially act as reservoirs for tick-borne zoonotic diseases.

Despite the widespread use of acaricides to control tick populations infesting dogs in urban and peri-urban areas, there is limited information on the control practices among dog owners in Wakiso, Uganda. These information gaps pose a significant challenge to effective tick control and the prevention of associated diseases in dogs and this study is aimed at filling these gaps and ultimately improving the health and wellbeing of the dogs.

1.3 General objective

To determine the prevalence and risk factors of ticks infesting dogs and tick control practices among dog owners in Wakiso, Uganda.

1.4 Specific objectives

i. To determine the prevalence of tick species infesting dogs in the study area.
ii. To identify the different tick control practices among dog owners.
iii. To identify factors associated with tick infestation in dogs.

1.5 Research questions

1. What is the prevalence of tick species infesting dogs in Wakiso, Uganda?
2. What are the different tick control practices among dog owners?
3. What are the factors associated with the tick infestation in dogs?

1.6 Justification

Dogs are important companion animals and act as reservoirs for zoonotic pathogens transmitted by ticks. The increasing global movement of pets through Entebbe International Airport creates a direct pathway for the introduction of non-native tick species and the pathogens they carry, which could establish themselves in the local environment and pose a threat to not only domestic dogs but also livestock, wildlife, and even humans.By understanding the common tick species infesting dogs and the different tick control practices, this study provides valuable data for informing veterinary practice and also aid in developing effective tick control strategies, ultimately improving the health and well-being of dogs and their owners.

CHAPTER TWO: LITERATURE REVIEW

2.1 Ticks infesting dogs

As part of class *Arachnida* -which also includes spiders, scorpions, and mites- ticks differ from insects due to their unsegmented, rounded bodies. There are two primary groups of ticks: hard ticks (*Ixodidae*) and soft ticks (*Argasidae*), alongside the unique *Nutalliellidae* family (Horak et al., 2002). Hard ticks, which are obligatory blood feeders, are notable for transmitting a wider variety of pathogens than any other arthropod. These ticks infest a range of vertebrates including domestic animals like dogs, and are key in spreading diseases to both humans and animals. Some tick species which have originally not been known to parasitize dogs in Africa have been found on roaming dogs in rural areas in Uganda, particularly *Amblyomma variegatum* (Proboste et al., 2015). The ecology of ticks in Africa is influenced by several factors, including host availability, temperature, and humidity (Dantas-Torres, 2010; Walker et al., 2003).

During a single feeding, *ixodid* ticks can ingest large volumes of blood, increasing the probability of acquiring pathogens from infected hosts. Additionally, while feeding, they inject saliva containing proteins that suppress the host's immune response. Their long lifespan, high reproductive ability, diverse host range, and resilience in harsh environments makes ticks exceptionally effective disease vectors (Perumalsamy et al., 2024). These parasites are notorious for their ability to transmit diseases such as canine ehrlichiosis, babesiosis, and anaplasmosis, causing significant morbidity and even mortality in dogs. Ticks feed on the blood of their hosts, a process that can result in severe dermatological reactions, anemia, and in severe cases, toxicosis (Dantas-Torres, 2010).

Uganda faces a significant threat from tick-borne diseases, which already cause substantial economic losses to its livestock sector (Day et al., 2020). However, there's a serious gap in research on the importation of new tick species into the country. While studies have focused on existing tick species and the growing problem of acaricide resistance (Day et al., 2020; Vudriko et al., 2016), there's a notable lack of recent data that specifically tracks the introduction of ticks from other parts of the world. A major contributing factor to this challenge is the increasing global travel of people with their pet dogs. Although Uganda has pet import regulations in place, including requirements for vaccinations and health certificates (MAAIF, 2023), these measures are not fully comprehensive or consistently enforced to prevent the entry of non-native ticks. This human habit creates a direct pathway for the introduction of new tick species and, critically, the novel disease pathogens they may carry, to which local animal and human populations have no immunity. This situation poses a silent but significant biosecurity risk.

2.2 Common Tick Species Infesting Dogs in Africa

2.2.1 *Rhipicephalus sanguineus*

The brown dog tick (*Rhipicephalus sanguineus*) is particularly adapted to urban environments. This tick is also known as the kennel or pan-tropical dog tick and it is the most widespread tick throughout the tropics and sub-tropics due to feeding on domestic dogs. *Rhipicephalus sanguineus* has the ability to complete its life cycle indoors, allowing it to infest homes and kennels. This species is a small Rhipicephalus, with a dull yellow color and some populations have a mid-brown color. Both sexes of this tick have spiracle plates and narrow tails with their width less than that of the adjacent festoon. This tick is not exclusive to only domestic dogs but it may be found on cattle. Dogs are hosts for all the stages of development and this tick is both domestic and monotropic. Adults attach on the ears, neck and shoulders, nymphs are found on the ears and shoulders, and larvae on the belly and flanks. Immature stages attach to humans and hosts, other than dogs are only infested when dogs are present (Walker et al., 2003).

This is a three-host tick and the engorged female detaches and lays approximately 3200 eggs within 7 to 28 days after detaching from a dog. Eggs hatch within 3 to 10 weeks and larvae engorge in 3 to 8 days and molt within 2 to 6 weeks. The nymphs then engorge in 4 to 10 days and molt within 2 to 26 weeks. The females engorge in 7 days but stay on the dog for 3 weeks when unmated and the males remain for several months for repeated matings. The life cycle is completed in 10 weeks under ideal conditions. The females climb up the walls and lay eggs in cracks and crevices or under the dog's bedding or in nearby cracks and crevices. The larvae and nymphs molt in the same sites as the females lay their eggs. *Rhipicephalus sanguineus* is known to transmit the bacterium *Ehrlichia canis* to dogs which is the causative agent for canine ehrlichiosis, and also transmits the bacterium *Rickettsia conorii* causing Boutonneuse fever in humans. This tick transmits the protozoans *Babesia canis* and *Babesia gibsoni*, causing canine babesiosis. During grooming, *Hepatozoon canis*, a protozoan is transmitted to the dog once it swallows the tick (Dantas-Torres, 2010; Walker et al., 2003).

2.2.2 *Haemaphysalis leachi*

Haemaphysalis leachi, the yellow dog tick, is one of the two ticks commonly found feeding on domestic dogs in tropical and sub-tropical regions but also in sub-Saharan Africa. This tick species has conspicuous lateral extensions to palp articles, forming mouthparts with a distinctive conical shape, the coxae of males have only medium length spurs. The other species in the same group are distinct in a way that *Haemaphysalis punctata* and *Haemaphysalis sulcata* both have small extensions to palp articles and very conspicuous spurs on the coxae of males. *Haemaphysalis spinulosa* is very similar to *Haemaphysalis leachi* but the female has spurs on the ventral surface of the palp articles. *Haemaphysalis paraleachi*, *Haemaphysalis punctaleachi* and *Haemaphysalis morel*i are difficult to distinguish from *Haemaphysalis leachi* and their host associations are similar (Walker et al., 2003).

Adult ticks are mainly hosted on domestic dogs and wild carnivores, such as the larger cats, foxes, jackals and wild dogs and immature stages prefer murid rodents, but may occur on the same hosts as the adults. Adult ticks attach on the head, neck and shoulders but in severe infestations they attach all over the body. *Haemaphysalis leachi* is rare on domestic cats. This tick species is a three-host tick; the female feeds for 1 to 2 weeks, engorging slowly initially but rapidly on the last day before detachment.

This tick lays approximately 5000 eggs within 7 to 28 days of detaching from the host animal. The eggs hatch within 2 to 9 weeks and after feeding, the larvae molts within 2 to 26 weeks and the nymphs within 2 to 7 weeks as adults are present throughout the year. This tick transmits the protozoan *Babesia canis*, causing canine babesiosis. Transmission is by the transovarial and transstadial routes. It also transmits the bacterium *Rickettsia conorii* to humans, causing tick typhus hence of great public health significance. This tick occurs in a wide range of climatic regions from rain forest to desert though sparse in desert areas. It has preference to warm and humid conditions, but it occurs wherever the rodent hosts for the immature stages are present in association with dogs; hosts for the adults. This tick is widespread in association with domestic dogs throughout the sub-Saharan Africa although often sparse on domestic dogs. Tick collections previously described as *Haemaphysalis leachi,* were examined in 2007 and many specimens were found to conform to another species; *Haemaphysalis elliptica*. And it was concluded that many of the southern and east African ticks previously identified as *Haemaphysalis leachi* are actually *Haemaphysalis elliptica* (Apanaskevich et al., 2007; Walker et al., 2003).

2.2.3 *Hyalomma truncatum*

Hyalomma truncatum is the shiny *Hyalomma* with males having a smooth surface. It is predominant in Africa, south of the Sahara where it is the commonest *Hyalomma* tick species infesting dogs. This tick causes direct damage to its hosts and is a distinctive *Hyalomma* tick when seen in male collections. These have a combination of a smooth, shiny and dark conscutum with a single large concave or depressed area in their posterior, having dense punctations giving a contrasting rough appearance. Females have a genital aperture with posterior lips forming a broad U shape with a concave pre-atrial fold profile. *Hyalomma truncatum* is a two-host tick, with adults preferring large domestic herbivores and wild herbivores. Domestic dogs are often infested and immature ticks attach to humans. These ticks infest dogs and cluster at one site causing severe skin necrosis. This species of ticks is adapted to dry habitats and commonest in the desert, steppe and savanna climatic regions, but also reported in highland climates. This tick is endemic to the Afrotropical zoogeographical region and is generally restricted to areas south of the Sahara. Although this tick species has been recorded from northern Sudan and Egypt. At a local level the abundance of this tick is influenced by the abundance of hares that are the preferred hosts of the immature stages (Walker et al., 2003).

2.2.4 *Ixodes pilosus*

Ixodes pilosus, the sourveld tick, is named so due to the pilose (hairy) appearance of the tick with conspicuous white setae and it has been documented in Africa to be infesting dogs. This tick occurs in the same areas as *Ixodes rubicundus* and these two species need to be differentiated. *Ixodes pilosus* belongs to the pilosus group of ticks and its status in this group remains uncertain. *Ixodes pilosus* is quite similar to *Ixodes rubicundus* whereby in both species the females have large white setae on the dorsal alloscutum, giving the ticks a shining white appearance although the effect is more distinct in *Ixodes pilosus*. On *Ixodes pilosus,* the setae are arranged in four columns whereas in *Ixodes rubicundus,* they are scattered over the dorsal alloscutum. *Ixodes* *pilosus* females have a scutum with a slightly sinuous posterior margin as compared to the distinctly sinuous margin in *Ixodes rubicundus*, which also shows a distinct constriction in the posterior part of the scutum. *Ixodes pilosus* has more distinct auriculae on the ventral surface of the basis capitula. The anal groove in *Ixodes pilosus* forms a short and converging pair of grooves in the area posterior to the anus as compared to the long and parallel pair in *Ixodes rubicundus*. Cattle, sheep, goats, dogs and wild ungulates are the hosts of *Ixodes pilosus* and it is a three-host tick. Adults of this tick may be found on dogs in large numbers which are likely to cause biting stress but it is not known to transmit any pathogens (Walker et al., 2003).

2.3 Effect of dog travels or movements on native tick populations and its health significance

Increased human mobility around the world elevates the risk of exposure of companion animals travelling with their owners or imported from other regions to tick infestation (Buczek & Buczek, 2021). Uganda's Ministry of Agriculture, Animal Industry, and Fisheries (MAAIF) has regulations for pet imports (MAAIF, 2023), primarily focused on preventing the introduction of major diseases like rabies. These measures are not fully comprehensive to prevent the entry of non-native ticks and this risk is elevated by the global trend of people traveling with their pet dogs on airlines, which could lead to the unintended importation of ticks.

Although there are no specific case studies published on tick importation into Uganda via air travel, the risk is well-documented globally. Many incidents of importation of ticks to new areas by animals transported by humans have repeatedly been described around the world. A classic example being the introduction of the Asian Longhorned tick (*Haemaphysalis longicornis*) into the United States of America where it had never been recorded before (Hayden, J. E.; Brambila, 2015). Buczek & Buczek (2021) suggest that the risk of transmission of pathogen-infected ticks by dogs and cats transported by humans has increased substantially in recent decades due to the rise in tourist and economic migration rates.

2.4 Tick control strategies and practices in dogs

Tick population control technologies and strategies have been studied for many years but no method is successful in all situations. Therefore, effective elimination of tick populations requires an integrated control strategy, targeting the canine population as well as the environment. This implies that all appropriate technological and management techniques are utilized, proportioning an effective decline of target populations in a cost-effective fashion. The approach includes both the use of chemical and non-chemical strategies and the success of each technology depends on the identity and abundance of the tick species, host species or host range, phenology of both ticks and hosts, geographic region, among other factors (White & Gaff, 2018).

2.4.1 Chemical tick control strategies

Tick control is primarily based on chemical means; whereby topical treatments have become the standard accepted method of application. Spot-on formulations and oral medication provide ease of use and a longer dosing interval (Barreto et al., 2021). More so, dogs are treated with a diverse range of veterinary preparations, such as spot-on formulations, impregnated collars, shampoos, sprays, dips, and powders. Fipronil, amitraz, carbaryl, and pyrethroids, are among the frequently used acaricides (Dantas-Torres, 2008).

Isoxazolines represent a major advancement in parasitic control for dogs globally, providing highly effective and long-lasting protection against fleas and ticks. These oral or topical medications, which include afoxolaner (NexGard), fluralaner (Bravecto), sarolaner (Simparica), and lotilaner (Credelio), have been widely adopted by veterinarians and pet owners due to their efficacy and convenient dosing schedules (Vudriko et al., 2018). They function by targeting and inhibiting gamma-aminobutyric acid (GABA)- and glutamate-gated chloride channels in the nervous systems of arthropods, leading to paralysis and death of the parasite with minimal effect on mammals (Shoop et al., 2014; Vudriko et al., 2018). The introduction of these compounds has revolutionized flea and tick management, as they are effective against many parasites that have developed resistance to older chemical classes (Vudriko et al., 2018).

Organophosphates (OPs), amitraz, synthetic pyrethroids (SPs), macrocyclic lactones (MLs), and fipronil are the commonly used acaricides. They act on the tick central nervous system through inhibiting acetylcholine-esterase (AChEs), affecting octopamine tyramine receptors, voltage-gated sodium channels, glutamate gated chloride channels (Glu-Cl), and GABA-receptors, respectively. These acaricides have specific targets and different modes of action, affecting the reproduction, growth and survival of various tick species (Obaid et al., 2022).

The use of acaricides on dogs is in most cases effective in eliminating tick infestations and preventing reinfestations during a given period of time. The frequency of treatment is dependent on the degree of infestation and the duration of the residual effect of the acaricide being used. The net time needed for the acaricide treatment to eliminate heavy tick infestations on the dog is uncertain and therefore, regular physical examination of treated dogs serves as an indicator of the progress for the tick control program (Dantas-Torres, 2008).

Use of acaricides in the environment in which the dog lives is often required in the control of certain tick species like *Rhipicephalus sanguineus*. In some situations, particularly in tropical and subtropical regions and in climate-controlled kennels, brown dog ticks usually infest buildings, with ticks crawling up walls, curtains and throughout the home or kennel, necessitating acaricides to be sprayed indoors into cracks and crevices, behind and under furniture or cages and along walls and the ceiling (Dryden, 2009). And this kind of treatment can be effective only when restricted areas are treated. The effectiveness of this strategy is dependent on a number of factors, such as: level of environmental infestation, presence of infestations in areas next to the treated one, residual effect of the acaricide, environmental conditions among others. However, there are many concerns as regards the use of the acaricides in the environment whereby their improper use causes environmental pollution, and toxicity to humans and other non-target organisms (Dantas-Torres, 2008).

2.4.2 Non-chemical tick control strategies and other strategies

Non-chemical procedures for tick control ought to be implemented along with chemical control methods. Ticks have many natural enemies (e.g., bacteria, fungi, and nematodes), and their biological control appears to be feasible since it has been shown that the use of entomopathogenic fungi, such as *Beauveria bassiana* and *Metarhizium anisopliae*, have the potential for controlling populations of certain tick species, including tick species infesting dogs (Dantas-Torres, 2008). Tick vaccines are being viewed as a cost-effective and environmentally friendly alternative against tick-borne diseases. This is because they control vector infestations and reduce pathogen transmission. These projected benefits have encouraged researchers to develop an effective vaccine against ticks, and several proteins are being characterized and used in native, synthetic, and recombinant forms as antigens in immunizations (Barreto et al., 2021).

Traditional control methods of ticks, such as use of acaricides and repellents, and educational campaigns on recommended practices to reduce dog exposure to ticks, have been partially successful. Drug resistance and contamination are important limitations to this success and despite the variety of acaricide products on the market, ticks remain an ongoing problem for dog owners (Barreto et al., 2021).

2.5 Risk factors associated with tick control in dogs

Tick control in dogs is a complex process influenced by a wide range of interrelated factors, including dog-related characteristics, owner knowledge and behavior, socioeconomic conditions, environmental contexts, product efficacy, and emerging acaricide resistance. According to Obaid et al. (2022), failures in tick control not only lead to heavy infestations but also increase the risk of tick-borne diseases and accelerate resistance to commonly used acaricides. Understanding these risk factors is therefore essential for designing sustainable and effective control strategies for companion animals.

One of the most important determinants of effective tick control is the dog owner's knowledge, attitude, and practice (KAP) towards tick management. Studies across various regions have consistently shown that low awareness of tick biology, improper product use, and inconsistent treatment intervals are associated with poor control outcomes(Namgyal et al., 2021; Tesfaye & Abate, 2023). Many owners lack adequate knowledge of when and how to apply tick control products, often misidentifying tick species or risk seasons, leading to misuse or delayed interventions. Furthermore, a lack of trust in veterinary guidance or reliance on informal advice encourages self-medication and the use of ineffective or counterfeit products (Panchim et al., 2024). Inadequate communication between veterinarians and dog owners compounds these risks, especially in communities where veterinary access is limited.

Socioeconomic status and access to quality veterinary care also play critical roles in determining tick control practices. Owners in low-income settings often face cost barriers that restrict their ability to purchase licensed acaricides or seek professional advice, forcing them to rely on cheaper or informal alternatives (Makwarela et al., 2025). Such practices often result in subtherapeutic dosing and inconsistent applications, contributing to tick persistence and acaricide resistance. Similarly, poor access to veterinary clinics and limited product availability lead to under-treatment or reliance on home remedies, both of which reduce control efficacy (Brophy et al., 2024). These access-related challenges highlight the importance of integrating socioeconomic considerations into tick management programs.

Dog-related factors such as age, breed, behavior, and husbandry practices have also been shown to influence infestation risk and control effectiveness. Free-roaming dogs, for example, are significantly more likely to harbor heavy tick infestations due to increased environmental exposure and contact with other infested animals. A 2024 study reported that roaming dogs were nearly six times more likely to be heavily infested than confined dogs (Jongejan et al., 2024). Young, intact, and poorly nourished dogs are similarly at higher risk, partly because of lower owner investment in preventive care and greater exposure to tick habitats (Tesfaye & Abate, 2023). Coat length and texture may also affect tick attachment rates and the ease of detection, influencing how consistently owners apply control measures.

Environmental and ecological conditions further shape the risk landscape. Vegetation density, humidity, and temperature all determine tick abundance and seasonal activity. In peri-urban and rural communities with heavy vegetation, free-roaming dogs and communal dog populations act as tick reservoirs, causing continuous re-infestation cycles even when individual owners apply control measures (Brophy et al., 2024). The lack of coordinated community-level interventions often results in re-infestation shortly after treatment, emphasizing the need for integrated control approaches that target both animals and the environment.

The efficacy of tick control products themselves presents another layer of complexity. Inappropriate product selection, incorrect dosing, and improper application reduce effectiveness and can encourage resistance development (Obaid et al., 2022). Continuous or indiscriminate use of a single acaricide class has been linked to resistance in *Rhipicephalus sanguineus* and *Haemaphysalis leachi*, two of the most common dog-infesting species (Panchim et al., 2024). Resistance emergence leads to treatment failures, prompting owners to either overuse products or abandon control altogether.

Poor-quality or counterfeit products circulating in unregulated markets exacerbate this issue and undermine public confidence in veterinary control methods (Makwarela et al., 2025).

The veterinary–client relationship and the broader regulatory environment also influence tick control practices. Veterinarians play a crucial role in advising on product choice, application frequency, and integrated management strategies. However, in many low-resource settings, veterinarians face constraints such as product shortages, client cost limitations, and limited diagnostic facilities (Panchim et al., 2024). Weak regulatory oversight allows the proliferation of substandard products, reducing the success of control programs. Strengthening the veterinary sector and enforcing product quality standards are therefore vital components of effective tick control strategies.

Social and cultural factors further contribute to the persistence of tick infestations. In some communities, owners perceive ticks as a minor nuisance rather than a health threat, reducing motivation to implement preventive measures. Norms that permit dogs to roam freely or that discourage regular grooming also increase infestation risks (Namgyal et al., 2021). Educational interventions and community awareness programs have been shown to improve owner behavior when culturally adapted and supported by local veterinary services (Brophy et al., 2024). Such programs help shift perceptions and encourage regular preventive care.

Overall, these factors interact dynamically to influence tick control outcomes. Poor knowledge and limited resources lead to inconsistent acaricide use, which in turn promotes resistance and reduces product efficacy. This feedback loop perpetuates infestation risk at both the household and community level. The literature therefore emphasizes the need for integrated pest management (IPM) approaches that combine owner education, veterinary engagement, environmental management, and regular resistance surveillance (Brophy et al., 2024; Obaid et al., 2022). Evidence also highlights the importance of subsidized preventive programs in low-income areas to reduce cost barriers and improve compliance (Makwarela et al., 2025). Despite growing research attention, significant gaps remain in longitudinal data linking owner practices, environmental factors, and resistance trends. Future studies should therefore focus on evaluating combined interventions across diverse ecological and socioeconomic contexts to inform sustainable, community-based tick control strategies.

CHAPTER THREE: MATERIALS AND METHODS

3.1 Study setting

Entebbe and Busiro South were purposively selected from Wakiso district, central Uganda due to their unique location and high-traffic status of people traveling with their dogs that creates a high-risk environment for the introduction of foreign tick species. This geographic juxtaposition of urban and rural environments provides a critical opportunity to compare and contrast the prevalence and risk factors of tick species infesting dogs and tick control practices among dog owners in an urban gateway versus a traditional agricultural setting, highlighting the interconnectedness of disease risks across the district.

3.2 Study design

A cross-sectional study design was conducted to achieve the objectives of the study. A combination of field data collection and laboratory analysis was used to gather the necessary data required for the two study objectives.

The dog owners were purposively selected from clients who visited Twiga Veterinary clinic and Entebbe Veterinary Center, two of the most pronounced veterinary clinics in the study area serving majority of the dog owners. More of the dog owners were gotten by snowball sampling technique. For households that had more than one dog, one dog was randomly selected and ticks collected when present. All dogs met in every household were considered for data collection regardless of any possibility of recent tick control done on them.

3.2.1 Sample size determination

The sample size of the study was determined using the Leslie Kish sampling formula (Tumuhamye et al., 2013) for Cross-sectional studies:

$$n = \frac{p(1-p)Z^2}{d^2}$$

Where:

- n = Number of dog owners

- Z= the standard normal value corresponding to the required confidence level (95%) = 1.96
- p = population proportion (assumed to be 0.5 since exact number of dog owners in the study area is unknown).
- d = the desired precision of the estimate (0.079)

Therefore, this study used a sample size of **153** respondents and one dog was sampled per respondent.

3.2.2 Tick collection

Ticks were collected from left side of the dog with more emphasis on the ears, neck, backline, under belly and area between paws in that order. Dogs with a long hair coat, the hair was turned in the opposite direction using gloved hands and all the visible ticks picked. Ticks were collected according to the standard operating procedure in Appendix 4. Male and female ticks were picked from the left side of the dog's body and placed in a sample collection bottle containing 70% ethanol, then transported to the Research Center for Tropical Diseases and Vector Control (RTC) laboratory at the College of Veterinary Medicine, Animal Resources and Biosecurity (COVAB), Makerere University for morphological identification.

3.2.3 Taxonomic identification of tick species collected

Adult ticks were identified to species level based on morphological keys provided by Matthysse & Colbo (1987) and Walker et al. (2003). The identified ticks in the sampled areas were categorized based on their species to determine the dominant tick species.

3.2.4 Collection of data on tick control practices among dog owners

An online questionnaire run on a kobo collect tool was used to gather data from 153 dog owners within the area of the study following standard operating procedures in Appendix 5. The data captured included the demographic characteristics of the dog owner, demographic characteristics of the dog, tick infestation of dogs (owner observations and experiences), tick control practices, effectiveness of tick control practices, safety of tick control practices, and disposal of wastes from tick control practices. The registration status of the acaricide brands or any other products mentioned by the dog owners was verified using the National Drug Authority's Veterinary Register (http://www.nda.or.ug/drug-register) and additional information on product registration was sought from National Drug Authority officials.

3.3 Data Management and Analysis

3.3.1 Data entry and cleaning

Data collected from questionnaires were exported from Kobo Collect into Microsoft Excel, where they were checked for completeness, consistency, and errors. After cleaning, the dataset was imported into Stata version 14.2 for analysis. Tick specimens collected from dogs were sorted, preserved and identified morphologically, and their distribution was coded and entered into the dataset.

3.3.2 Descriptive statistics

Frequencies, percentages, means, and standard deviations were used to summarize:

1. Tick infestation levels among sampled dogs.
2. Demographic characteristics of dog owners.
3. Attributes of dogs (sex, purpose, breed, housing).
4. Tick control practices reported by dog owners.

Findings were presented in tables, graphs and charts for clarity.

3.3.3 Comparative analysis

Chi-square (χ^2) tests were used to assess variations in dog owner practices in relation to tick infestation status. A P-value < 0.05 was considered statistically significant.

The formula below was used to compute the Pearson's Chi-square coefficient.

$$\chi^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

Where:

χ^2 is the Chi-square statistic.

O_i is the observed frequency.

E_i is the expected frequency.

To calculate expected frequency

$$E_i = \frac{\text{(Row Total)(Column Total)}}{\text{Grand Total}}$$

3.3.5 Risk Factor analysis

Multivariate logistic regression was performed to evaluate risk factors associated with the presence of ticks on the dog. Results were expressed as odds ratios with 95% confidence intervals. Model fit was assessed and significant predictors were interpreted in line with study objectives.

3.4 Ethical considerations

Informed consent was obtained from all dog owners before tick collection and administration of the online questionnaire. Consent forms explained the background and rationale for the study, purpose, the procedures involved, benefits, confidentiality of the data collected and contact information in case of questions about the study, and questions about participant rights.

Tick collection was conducted in a manner that does not harm the dogs. All procedures complied with international and local dog welfare guidelines, ensuring that the dogs were not subjected to undue stress or discomfort. All persons involved in the collection of ticks from dogs on the research team were vaccinated against Rabies virus and trained on the most appropriate methods of restraint for dogs.

CHAPTER FOUR: RESULTS

4.1 Introduction

This chapter presents the findings of the study based on the data collected on ticks infesting dogs and the control practices used by dog owners. The results are organized and interpreted in line with the study objectives, identifying the common tick species infesting dogs and the tick control practices used by dog owners.

4.3 Demographic characteristics of Dog owners in the study area

A total of 153 dog owners, 111 from Entebbe and 42 from Busiro south were included in this study. Most (34.0%, n = 52) of the dog owners were aged 35 to 44 years, majority (62.1%, n = 95) were males and 82.4% (n = 126) had attained post-secondary education. Most (45.8%, n = 70) of the dog owners engaged in business and 75.8% (n = 116) of them had kept dogs for more than 6 years. All the attributes of the studied dog owners did vary significantly between Entebbe and Busiro south ($P > 0.05$) as summarized in Table 1.

Table 1: Demographic characteristics of dog owners in Entebbe and Busiro South

Variable	Entebbe (n = 111)	Busiro South (n = 42)	Overall (n = 153)	*P* – value
Age (years), n (%)				
<18	1 (0.9)	0 (0.0)	1 (0.6)	0.253
19-24	6 (5.4)	1 (2.4)	7 (4.6)	
25-34	25 (22.5)	10 (23.8)	35 (22.9)	
35-44	32 (28.8)	20 (47.6)	52 (34.0)	
45-54	34 (30.6)	9 (21.4)	43 (28.1)	
>=55	13 (13.7)	2 (4.8)	15 (9.8)	
Sex, n (%)				
Male	74 (66.7)	21 (50.0)	95 (62.1)	0.058
Female	37 (33.3)	21 (50.0)	58 (37.9)	
Education, n (%)				
No formal education	1 (0.9)	0 (0.0)	1 (0.6)	0.829
Primary	2 (1.8)	1 (2.4)		
Secondary	18 (16.2)	5 (11.9)	23 (15.0)	
Post-secondary	90 (81.1)	36 (85.7)	126 (82.4)	
Occupation, n (%)				
Student	4 (3.6)	1 (2.4)	5 (3.3)	0.360
Civil servant	26 (23.4)	15 (35.7)	41 (26.8)	
Business owner	51 (45.9)	19 (45.2)	70 (45.8)	
Other	30 (27.0)	7 (16.7)	37 (24.2)	
Duration in dog keeping (years), n (%)				
< 1	5 (4.5)	2 (4.8)	7 (4.6)	0.877
1 – 3	12 (10.8)	3 (7.1)	15 (9.8)	
4 – 6	10 (9.0)	5 (11.9)	15 (9.8)	
> 6	84 (75.7)	32 (76.2)	116 (75.8)	

4.4 Demographic characteristics of dogs in Entebbe and Busiro south

Majority (71.9%) of the dogs were males, 70.0% were kept to offer security to their owners, and shepherd dogs were the dominant as detailed by Figure 4

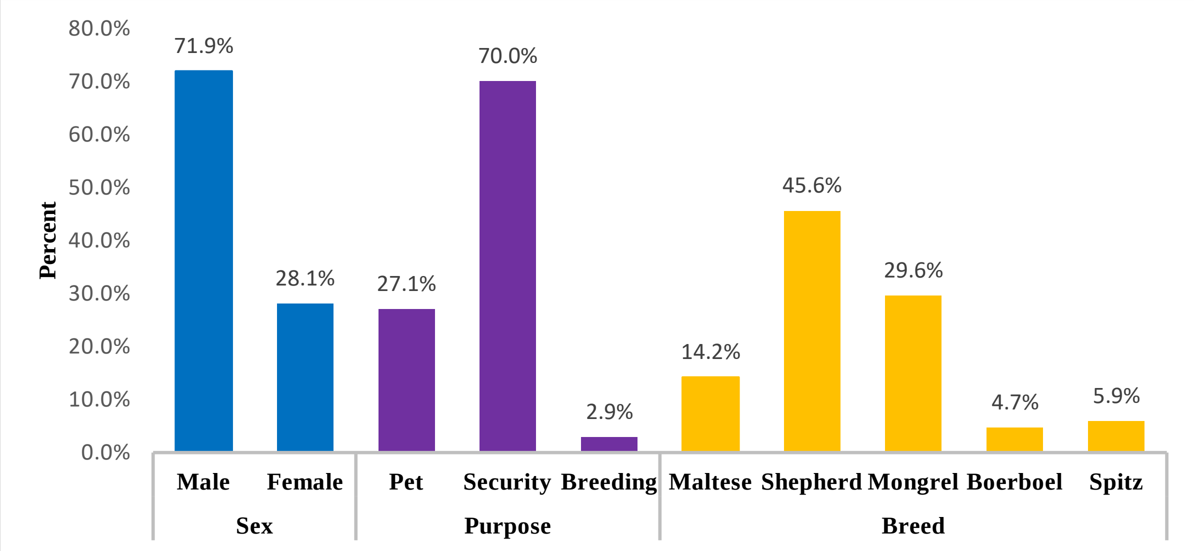

Figure 1: Attributes of dogs in Entebbe and Busiro South

4.2 Tick species infesting dogs in Entebbe and Busiro South

A total of 310 adult ticks from the ticks collected from the 69 dogs which were found with ticks during data collection out of the 153 dogs sampled; 99.68% (n = 309) of them were of species *Rhipicephalus sanguineus* and only 0.32% (n = 1) were of species *Haemaphysalis leachi*. These findings are presented in Figure 2.

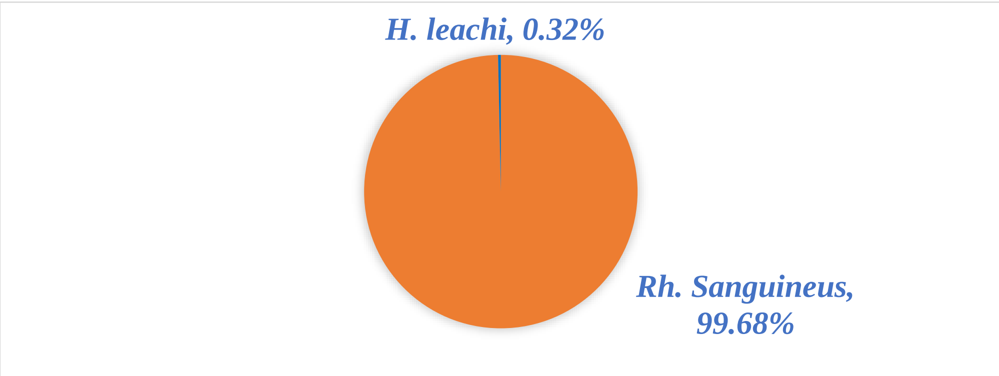

Figure 2: Tick species identified on dogs from Entebbe and Busiro South

Overall, the occurrence of ticks was higher (55.5%, 172/310) on dogs from Entebbe compared to those from Busiro South but this difference in the occurrence of ticks was not statistically significant (P = 0.054). A significantly higher proportion (55.7%, 172/309) of *Rh. Sanguineus* ticks were obtained from dogs in Entebbe compared to 44.3% (137/309) obtained from dogs in Busiro south (P = 0.046). On the other hand, (100%, 1/1) of the *H. leachi* ticks was obtained from 1 dog in Busiro south as summarized in Table 2.

Table 2: Common ticks infesting dogs in Entebbe and Busiro south

Ticks	Entebbe, n (%)	Busiro south, n (%)	*P* – value
***Rh. sanguineus* (n = 309)**	172 (55.7)	137 (44.3)	**0.046**
***H. leachi* (n = 1)**	0 (0.0)	1 (100.0)	-
Overall (n = 310)	**172 (55.5)**	**138 (44.5)**	0.054

A B C

Ventral view; A- female Rh. Sanguineus, B- male Rh. Sanguineus, C- male H. leachi

D E F

Dorsal view; D- female Rh. Sanguineus, E- male Rh. Sanguineus, F- male H. leachi

Figure 3: Tick species identified in the study area

4.4 Practices of Dog owners regarding tick control by occurrence of ticks on dogs

From this study, majority (69.3%, n = 106) of the dog owners kept their dogs in kennels, most (66.0%, n = 101) of the dog owners allowed their dogs to spend their time primarily indoors and 56.9% (n = 87) of the dog owners did not allow their dogs to interact with other animals. 47.1% (n = 71) of the dog owners groomed/washed their dogs on a monthly basis, most (41.2%, n = 63) of the dog owners used topical applications to control ticks in dogs, and 45.1% (n = 69) of the dog owners obtained advice regarding tick control from a veterinarian. 39.9% (n = 61) of the dog owners did not control ticks on their dogs and most (52.9%, n = 81) of them did not change the acaricide product if the tick did not die following use of a given product. The findings of this study also revealed that the frequency of dog grooming/washing ($P = 0.005$), method of tick control ($P < 0.001$), source of advice on tick control ($P < 0.001$), source of the tick control product ($P < 0.001$), the driver of the dog owner to control ticks ($P < 0.001$), and whether the dog owner changes the acaricide if a bad response was encountered ($P < 0.001$) were associated with occurrence of ticks on dogs. These findings are summarized in **Error! Reference source not found.**.

Table 3: Practices of dog owners regarding tick control in by occurrence of ticks on dogs

Dog owner practice	+Ticks*AD* (n = 84)	+Ticks*PD* (n = 69)	Overall (n = 153)	+*P* – value
Dog housing, n (%)				
Kennel	58 (55.7)	47 (44.3)	106 (69.3)	0.288
Shares house with the owner	19 (61.3)	12 (38.7)	31 (20.3)	
Free-roaming	6 (37.5)	10 (62.5)	16 (10.4)	
Primary location of the dog, n (%)				
Indoors	62 (61.4)	39 (38.6)	101 (66.0)	0.051
Outdoors	11 (50.0)	11 (50.0)	21 (14.4)	
Both	11 (36.7)	19 (63.3)	30 (19.6)	
The dog interacts with other animals, n (%)				
Yes	31 (47.0)	35 (53.0)	65 (43.1)	0.086
No	53 (60.9)	34 (39.1)	87 (56.9)	
Frequency of dog grooming/bathing, n (%)				
Daily	2 (100.0)	0 (0.0)	2 (1.3)	**0.005**
Weekly	30 (68.2)	14 (31.8)	44 (28.7)	
Monthly	29 (40.3)	43 (59.7)	71 (47.1)	
Rarely	23 (65.7)	12 (34.3)	35 (22.9)	
Tick control method, n (%)				
None	52 (85.3)	9 (14.7)	61 (39.9)	**< 0.001**
Manual removal	1 (20.0)	4 (80.0)	5 (3.2)	
Topical (shampoo/washes)	21 (33.3)	42 (66.7)	63 (41.2)	
Oral tablets	9 (39.1)	14 (60.9)	23 (15.0)	
Acaricide – collars	1 (100.0)	0 (0.0)	1 (0.7)	
Source of advice on tick control, n (%)				
None	52 (85.3)	9 (14.7)	61 (39.9)	**< 0.001**
Fellow dog owner	3 (30.0)	7 (70.0)	10 (6.5)	
Personal research	3 (23.1)	10 (76.9)	13 (8.5)	
Veterinarian	26 (37.7)	43 (62.3)	69 (45.1)	
Source of the tick control product, n (%)				
None	52 (85.3)	9 (14.7)	61 (39.9)	**< 0.001**
Pet shop	11 (28.2)	28 (71.8)	39 (25.5)	
Vet clinic	21 (39.6)	32 (60.4)	53 (34.6)	
What drives the dog owner to control ticks, n (%)				
None	52 (85.3)	9 (14.7)	61 (39.9)	**< 0.001**
When I observe ticks	3 (10.3)	26 (89.7)	29 (18.9)	
After advice	8 (40.0)	12 (60.0)	20 (13.1)	
I follow a regular schedule	21 (48.8)	22 (51.2)	43 (28.1)	
Changes acaricide if a negative response is observed, n (%)				
None	52 (85.3)	9 (14.7)	61 (39.9)	**< 0.001**
Yes	1 (9.1)	10 (90.9)	11 (7.2)	
No	31 (38.3)	50 (61.7)	81 (52.9)	

+PD – dog with ticks and AD – Dog without ticks, +*P* - value for chi-squared test.

4.6 Risk factors for tick infestation in dogs in Wakiso, Uganda

A multivariate logistic regression was done on the factors whose p-value was equal or less than 0.25 and primary location of the dog, frequency of dog grooming, tick control method, source of advice on tick control, and source of tick control product were not statistically significant. Dogs that interact with other animals were 2.2 times more likely to be found with ticks (OR = 2.2 , 95%CI = 0.9-5.5) compared to those that did not interact with other animals. Dog owners that follow a regular schedule to control ticks were 92% less likely to find ticks on their dogs (OR = 0.08, 95% CI = 0.02-0.4)

Figure 4: Logistic regression analysis of risk factors for tick infestation in dogs in the study area

Factor	Tick infestation Present, n (%)	cOR (95%CI)	P-value	aOR (95%CI)	P-value
The dog interacts with other animals		1.76 (0.9-3.4)	0.087	2.4 (1.0-5.9)	**0.046**
No	34 (39.1)	1		1	
Yes	35 (53.0)	1.76 (0.9-3.4)	0.087	2.2 (0.9-5.5)	0.103
Tick control method		2.3 (1.6-3.1)	**< 0.001**	1.9 (0.8-4.7)	0.138
Manual removal	4 (80.0)	1		1	
None	9 (14.7)	0.04 (0.004-0.4)	**0.008**	0.03 (0.001-0.6)	**0.022**
Topical (shampoo/washes)	42 (66.7)	0.5 (0.1-4.8)	0.547	1.7 (0.1-29.8)	0.719
Oral tablets	14 (60.9)	0.39 (0.04-4.1)	0.43	1.8 (0.1-42.1)	0.701
Acaricide – collars	0 (0.0)	-		-	
What drives the dog owner to control ticks		1.6 (1.2-2.1)	**0.001**	0.4 (0.2-0.7)	**0.005**
When I observe ticks	26 (89.7)	1		1	
None	9 (14.7)	0.02 (0.01-0.1)	**< 0.001**	-	
After advice	12 (60.0)	0.17 (0.04-0.8)	**0.021**	0.1 (0.02-0.6)	**0.013**
I follow a regular schedule	22 (51.2)	0.12 (0.03-0.5)	**0.002**	0.08 (0.02-0.4)	**0.03**

4.5.1 Severity of tick infestations

91.30% of the dog owners that had previously observed ticks on their dogs reported mild tick infestations and 8.70% reported moderate tick infestations.

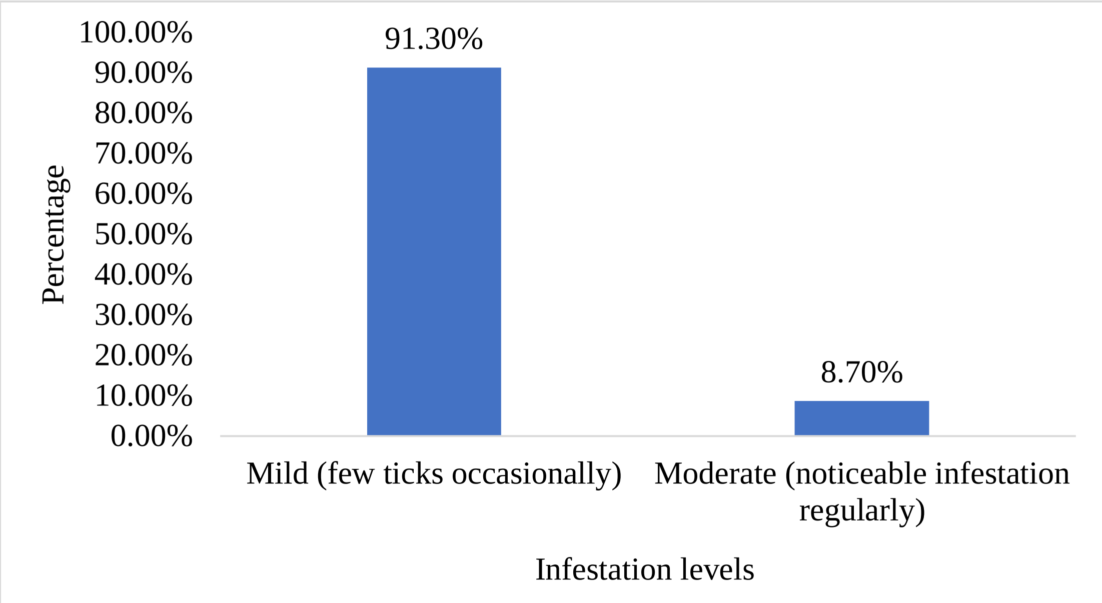

Figure 5: Severity of tick infestations reported by dog owners

4.6 Types of chemicals/ drugs used for control of ticks and their registration status

Fip-Tox (26.53%) is the most used acaricide, followed by Bravecto (25.51%) among others. Dog owners in the study area mostly used Fipronil products and Fluralaner for tick control as shown in Table 6 below;

Table 4: Chemicals/ drugs used for control of ticks in Entebbe and Busiro South

Class of chemicals	Trade name	Chemical name	Registration status	Frequency (%)
Acaricides	Fip-tox	Fipronil	Registered	26(26.53)
	Frontline spray	Fipronil	Registered	2(2.04)
	Frontline plus	Fipronil	Registered	1(1.02)
	Fipron	Fipronil	Registered	2(2.04)
	Amitix	Amitraz	Registered	10(10.2)
	Utravin (Dudu dust)	carbaryl, permethrin	Registered	4(4.08)
	Cypertix 10%	Alphacypermethrin	Registered	1(1.02)
	Sangaphos	Organophosphate	Registered	1(1.02)
	Alfapor	Alphacypermethrin	Registered	1(1.02)
	Bravecto	Fluralaner	Registered	25(25.51)
	Simparica	Sarolaner	Registered	1(1.02)
	Nexgard	Afoxolaner	Unknown	2(2.04)
Medicated shampoo	Combat shampoo	Permethrin	Registered	14(14.29)
	Fur medicated dog shampoo	-	Unknown	3(3.06)
	Bravo dog shampoo	Cypermethrin	Registered	2(2.04)
	Bob Martin Flea and Tick Shampoo	Pyrethrum Extract (Pyrethrins), Cypermethrin, Permethrin	Registered	1(1.02)
	Castro medicated dog shampoo	-	Unknown	1(1.02)
Acaricidal collars	Bob Martin Clear Flea & Tick Repellent Collar for Dogs	Dimpylate (Diazinon), Margosa extract and Lavandin oil.	Registered	1(1.02)

CHAPTER FIVE: DISCUSION

The main aim of this study was to determine the prevalence and risk factors of tick species infesting dogs and tick control practices used by dog owners in Wakiso, Uganda. This study identified two tick species infesting dogs in Wakiso, Uganda: *Rhipicephalus sanguineus* and *Haemaphysalis leachi*. The dominance of *R. sanguineus* (99.68%) agrees with reports across Africa and other tropical regions where it is the most widespread tick of domestic dogs (Dantas-Torres, 2010; Matthysse & Colbo, 1987; Walker et al., 2003). Its success can be attributed to its ability to complete its life cycle on dogs and adapt to peridomestic environments (Jongejan & Uilenberg, 2004). 66.0% of the dogs spend their time primarily indoors and 69.3% of the dog owners in the study area keep their dogs in kennels. This tick species is reported to have the ability to complete its life cycle indoors, allowing it to infest homes and kennels(Walker et al., 2003) This predominance however is of veterinary and public health concern, as *R. sanguineus* ticks transmit pathogens to dogs and humans. *Rh. sanguineus* has been reported in the transmission of *Ehrlichia canis* to dogs which is the causative agent for canine ehrlichiosis, and *Rickettsia conorii* causing Boutonneuse fever in humans (Dantas-Torres, 2008, 2010; Proboste et al., 2015). This tick has also been reported in the transmission of *Babesia canis* and *Babesia gibsoni*, causing canine Babesiosis (Walker et al., 2003). Zahri et al. (2025) reported that this tick is important in the transmission of *Hepatozoon canis*, to dogs once swallowed during grooming.

The detection of a single *H. leachi* specimen suggests its presence is sporadic. This is as opposed to a report by Proboste et al. (2015) that found out that *H. leachi* was the most prevalent tick species around three conservation areas in south- western Uganda representing almost 70 % of the retrieved ticks. This however is most probably due to host-tick interactions attributed to the housing and where dogs primarily spend their time. Reports suggest that, *H. leachi* ticks occur wherever the rodent hosts for the immature stages are present in association with dogs although often sparse on domestic dogs (Apanaskevich et al., 2007; Walker et al., 2003). 56.9% of the dogs do not interact with other animals according to our study. This signifies that there is a very low likelihood of dogs interacting with rodent hosts for the immature stages as opposed to the free roaming dogs that were involved in the study by Proboste et al. (2015). Only a single tick of this species was found in the study area, however this does not underscore its importance in the transmission of *Babesia rossi* (Proboste et al., 2015) , the most pathogenic for dogs among the three subspecies of *B. canis*, and it frequently causes a fatal infection despite intensive treatment.

Majority of the dog owners (66.0%) kept their dogs indoors, with 14.4% and 19.6% outdoors and both environments respectively. This is in agreement with a survey conducted by Panchim et al. (2024) in Thailand where dog owners reported keeping their dogs indoors, outdoors, and in a mixed environment at rates of 68.2%, 8.0%, and 23.8%, respectively. Topical acaricides and shampoos (41.2%) were the most commonly used tick control practices by dog owners, while a notable proportion of dog owners (39.9%) did not practice any form of tick control. The absence of intervention in such a large proportion of dogs provides a favorable environment for continued tick proliferation, consistent with earlier reports that irregular or absent tick control is a major driver of sustained infestations in companion animals (Kamani et al., 2013). Majority (45.1%) of the dog owners obtained advice regarding tick control from a veterinarian. This finding corelates with a report from Thailand that most pet owners (80.12%) frequently use tick prevention products recommended by veterinarians (Panchim et al., 2024).

In the study, 28.1% the dog owners followed a regular schedule for tick control and were 92% less likely to have ticks on their dogs (OR = 0.08, CI = 0.02-0.4). This highlights the importance of consistent application of tick control practices. Dogs that interact with other animals were 2.2 times more likely to have ticks (OR = 2.2, 95% CI = 0.9-5.5) compared to those that did not interact with other animals. This is due to tick-host interactions that maintain the tick population even after application of the tick control practice on the dogs. The other animals act as alternative hosts during this time or are intermediate hosts for the developmental stages sustaining the tick population in the environment of the dog.

The use of both registered and unregistered acaricides reflects regulatory gaps that could compromise long-term effectiveness. While fipronil and permethrin based products dominated among registered drugs, a newer molecule, afoxolaner was also in use despite lacking local registration. The reliance on unverified products not only raises concerns about safety but may also accelerate acaricide resistance, already recognized as a global challenge (Vudriko et al., 2016).

This study had several limitations that should be considered when interpreting the findings. First, tick identification was conducted using morphological methods and only adults were identified, which, although widely applied, may not detect cryptic or closely related species; the inclusion of molecular techniques would have provided more precise confirmation. Second, the relatively small sample size and narrow geographic scope may have limited the detection of less common or non-native tick species, which could be present in the wider dog population but were not captured in this study. Third, the cross-sectional design provided only a single-time snapshot of tick infestations and owner practices, thereby excluding seasonal variations known to influence both tick abundance and control behaviors. Fourth, reliance on self-reported data from dog owners introduced the risk of recall and social desirability bias, potentially leading to underreporting of poor practices or overestimation of compliance. Finally, the assessment of acaricide effectiveness was based on owner perception and presence or absence of ticks regardless of the most recent time of application of the tick control practice rather than objective parasitological evaluation, which may not accurately reflect true efficacy. Despite these limitations, the study offers important baseline insights into the prevalence and risk factors of tick species infesting dogs and control practices among dog owners in Wakiso, Uganda. Some of the above limitations were mitigated and minimized by collecting data for a period of three months, starting from July until the end of September, providing an extended period to assess variations in different time seasons. Also, an investigator’s check list attached in appendices was utilized to record the actual data based on observation. This integration of observational methods with owner interviews minimized recall and social desirability bias, providing a more objective understanding of management behaviors.

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

This study demonstrated that *Rhipicephalus sanguineus* is the predominant tick species infesting dogs in Wakiso-Uganda, with owner practices playing a critical role in determining infestation levels. While many dog owners used topical acaricides and shampoos, a significant proportion did not implement any tick control, contributing to the persistence of infestations. Veterinary advice and consistent use of effective, registered products were associated with better outcomes, while irregular practices and reliance on unverified sources reduced effectiveness. Dogs interacting with other animals and when the dog owner decided to control ticks were the major risk factors for tick infestation. However, the reliance on owner perceptions, small sample size, and cross-sectional design limited the scope of conclusions, particularly regarding non-native or rare tick species. Despite these constraints, the study provides important baseline insights for prevalence and risk factors for tick species infesting dogs in Wakiso-Uganda as well as key tick control practices among dog owners. These findings may guide dog owners to improve canine health and welfare but also mitigate the wider public health risks posed by tick-borne zoonoses.

6.2 Recommendations

1. Veterinary authorities should strengthen regulation and monitoring of acaricide distribution to limit the use of unregistered or counterfeit products, which may compromise effectiveness and accelerate resistance.Dog owners should be encouraged to adopt integrated tick control strategies that combine chemical treatment, regular bathing, kennel hygiene, and reduced contact with stray animals.
2. Most importantly, collaboration between local government, veterinary professionals, and community leaders is needed to promote responsible dog ownership and reduce the risk of tick-borne diseases in Wakiso - Uganda.

6.3 Future prospects

Future studies on dog tick infestations and control practices in Uganda should address the limitations identified in this research. First, molecular techniques such as PCR and sequencing should be incorporated alongside morphological identification to improve accuracy and capture cryptic or closely related tick species that may have been overlooked. Larger sample sizes drawn from multiple ecological zones across the country would improve representativeness and increase the likelihood of detecting less common or non-native tick species. Longitudinal or seasonal studies are recommended to capture temporal dynamics of tick populations and variations in owner practices throughout the year. Finally, controlled field trials evaluating the efficacy of commonly used acaricides would provide stronger evidence on effectiveness than self-reported perceptions. Addressing these areas will strengthen the knowledge base for designing sustainable, evidence-driven tick control strategies in both peri-urban and rural Ugandan settings.

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APPENDICES

Appendix I: Consent Form for Data Collection

Study Title: **Prevalence and Risk Factors of Tick Species Infesting Dogs and Tick Control Practices among Dog Owners in Wakiso - Uganda**

Investigator: **Rogers Byarugaba**

Background and rationale for the study

Tick-borne diseases are increasingly becoming a serious health concern for dogs worldwide, including Uganda. These diseases not only threaten canine health but also pose risks to humans, as dogs can serve as reservoirs for zoonotic diseases. Although ticks on domestic animals in Africa have been studied, little is known about the tick species infesting dogs in Uganda with the most recent and comprehensive literature dating to 1987.

There is limited information on the different tick control practices being used by dog owners in Uganda. And this study aims to address that gap by providing critical data to guide effective tick control measures in dogs but also highlight the health significance of the common tick species infesting dogs in Wakiso - Uganda.

Purpose:

a) To determine the prevalence of tick species infesting dogs in Wakiso - Uganda.
b) To identify the common tick control practices among dog owners.
c) To identify the risk factors associated with tick infestation.

Procedures:

You have been included as a candidate to participate in this study because you keep dogs at your home. You will be asked by the investigator to respond to questions regarding your dog(s), tick control practices being employed, and your experiences with ticks. This will take approximately 30 minutes to complete and you will have the right to review the data collected from you. Ticks will be collected from your dog and one dog will be sampled per household.

There are minimal risks associated with participating in this study; you will be asked to recall some information about your dog's health and tick encounters, which might cause minor emotional discomfort. You will also be asked to restrain your dog before ticks are collected from it.

Benefits

You will be the first person to receive feedback on the results obtained from the study; and you knowing about the different tick control practices being employed by fellow dog owners and their effectiveness will guide you to the most effective tick control practices for your dog.

Confidentiality

Your name and other identifying information will be kept confidential and will not be linked to your answers in any reports or publications resulting from this study. All data will be stored securely in a password-protected file and only accessible to the research team. The collected data will be used for research purposes only; this may include publications in academic journals, presentations at conferences, or reports to relevant organizations.

Questions:

In case you have any questions related to the study, you can contact the Investigator on 0751408686 or on email rogersbyarugaba27@gmail.com

Questions about participants rights:

In case you have any questions regarding your rights as a dog owner, you can contact the Chairperson, School of Veterinary Medicine & Animal Resources (SVAR) Research and Ethics Committee; Dr. Lali Dominic Mundrugo-Ogo on 0772540415 or on email dmundrugolali@gmail.com

Consent

I have been explained to the details of the study; I have asked questions and they have been satisfactorily answered and I am willingly consenting to participate. By signing in the space below, I confirm that my participation is voluntary. A copy of this document will be given to you to keep.

Name...Sign................................ Date........................

For those unable to read and write

Name of witness.. Thumb print of participant

Sign..

Date..

Name of person obtaining consent Sign.............................. Date.........................

....

Appendix II: Questionnaire

GPS Location: …………………………… Q: Code **001**

Section 1: Demographic Characteristics of the Owner

1. What is your name? (optional)

   ………………………………………………………….

2. What is your location?

1. Village ……………………………….
2. Parish …………………………………
3. Subcounty …………………………….
4. Division ……………………………….

3. How old are you (in years)?

   ☐ Below 18

   ☐ 18–24

   ☐ 25–34

   ☐ 35–44

   ☐ 45–54

   ☐ 55 and above

4. What is your gender identity?

   ☐ Male

   ☐ Female

   ☐ Prefer not to say

5. What is your highest level of formal education attained?

   ☐ No formal education

   ☐ Primary school

   ☐ Secondary school

   ☐ Tertiary/College (Diploma/Certificate)

   ☐ University Degree

   ☐ Postgraduate (Masters/PhD)

6. What is your occupation?

☐ Farmer

☐ Civil servant

☐ Business owner

☐ Student

☐ Veterinary personnel

☐ Other (specify): …………………………………

7. For how long have you been keeping dogs?

☐ Less than 1 year

☐ 1–3 years

☐ 4–6 years

☐ Over 6 years

Section 2: Demographic characteristics of the dog

No.	Dog Name	Breed	Sex	Age
1.				
2.				
3.				
4.				
5.				

8. What is the primary purpose of keeping your dog(s)? (Tick all that applies)

☐ Pet

☐ Security

☐ Hunting

☐ Breeding

☐ Other (specify): …………………………….

9. How is your dog housed? (Tick all that applies)

☐ Free-roaming

☐ Tethered

☐ Kennel (sheltered)

☐ Indoors

☐ A combination of the above

10. Where does(do) your dog(s) primarily spend its(their) time?

☐ Indoors ☐ Outdoors ☐ Both

11. Does(do) your dog(s) regularly interact with other animals?

☐ Yes ☐ No

12. If yes, which of the following animals does it interact with? (Tick all that applies)

☐ other dogs

☐ cats

☐ livestock

☐ wild animals

☐ others (specify): ………………………………………………

13. How often is the dog bathed or groomed?

☐ Daily

☐ Weekly

☐ Monthly

☐ Rarely

Section 3: Tick infestation of dogs(Owner Observations & Experiences)

14. Have you ever observed ticks on your dog(s)?

☐ Yes

☐ No

15. If yes, how often do you observe ticks on your dog(s)?

☐ Daily

☐ Weekly

☐ Monthly

☐ Occasionally

☐ Never

16. Where do you usually find the ticks on your dog? (select all that apply)?

☐ Ears

☐ Neck

☐ Armpits

☐ Between toes

☐ Tail area

☐ Groin

☐ Under belly

☐ Entire body

☐ Other (specify): ………………………

17. In which season do you observe the highest tick infestation?

☐ Wet season

☐ Dry season

☐ Both seasons

☐ No seasonal variation

18. How severe are the tick infestations on your dog(s)?

☐ Mild (few ticks occasionally)

☐ Moderate (noticeable infestation regularly)

☐ Severe (heavily infested often)

19. Have the ticks ever caused health issues for your dog(s)?

☐ Yes (specify): …………………………

☐ No

☐ I don't know

20. Do you know the type of ticks affecting your dog?

☐ Yes (specify): …………………………….

☐ No

21. Describe the typical size and appearance of the ticks you usually find on your dog? (e.g., small/large, color, any distinct markings)

……………………………………………………………………………………

Section 4: Tick control practices

22. Do you currently use any method to control ticks on your dog(s)?

☐ Yes

☐ No

23. If yes, which method(s) do you use to control ticks on your dog(s)? (Tick all that apply)

☐ Topical acaricides

☐ Collars (acaricidal collars)

☐ Oral acaricides

☐ Shampoos/washes

☐ Manual removal

☐ Home remedies (e.g., oils, herbs)

☐ Other (Please specify): ………………………….

☐ I do not use any tick control methods.

24. If you use topical acaricides:

a. What is the

Product(Brand) name?	Cost(Shs)?

b. How often do you apply the topical acaricide?

☐ Daily

☐ Weekly

☐ Monthly

☐ After 3 months

☐ After 6 months

☐ Irregularly

c. Where do you apply the topical acaricide on your dog(s)?

☐ Between the shoulder blades

☐ Along the back

☐ Ears

☐ Neck

☐ Armpits

☐ Between toes

☐ Tail area

☐ Groin

☐ Under belly

☐ Entire body

☐ Other (specify): …………………….

d. How is it applied?

☐ spot-on treatments

☐ sprays

☐ dip solutions

☐ other(specify): …………………...

25. Are there challenges you experience with regard to application of the topical acaricides on your dog?

☐ Yes

☐ No

26. If yes, please specify:

…………………………………………………………………………………………

27. If you use acaricidal collars:

a. What is the

Brand or model name?	Cost(Shs)?

b. How often do you replace the collar?

☐ Daily

☐ Weekly

☐ Monthly

☐ After 3 months

☐ After 6 months

☐ other(specify): ……………………………

28. If you use oral acaricides:

a. What is the

Product (Brand) name?	Cost (Shs)?

b. What is the dosage you administer to your dog(s)?

……………………………………………………………………………………..

c. How often do you administer the oral acaricide?

☐ Daily

☐ Weekly

☐ Monthly

☐ After 3 months

☐ After 6 months

☐ other(specify): …………………………….

d. How do you administer the oral acaricide?

☐ Oral tablets

☐ Drench solution

29. If you use shampoos/washes:

a. What is the

Product(Brand) name?	Cost(Shs)?

b. How often do you wash your dog(s) with the shampoo?

☐ Daily

☐ Weekly

☐ Monthly

☐ After 3 months

☐ After 6 months

☐ other(specify) : …………………………….

30. If you manually remove ticks, what tools do you use?

………………………………………………………………………………………

31. If you use home remedies,

a. please specify the remedies

………………………………………………………………………………………

b. how often do you apply them?

☐ Daily

☐ Weekly

☐ Monthly

☐ After 3 months

☐ After 6 months

☐ other(specify): ………………

c. how do you apply them?

☐ spot-on treatments

☐ sprays

☐ dip solutions

☐ drench solutions

☐ other(specify): ……………………….

32. Who advised or influenced your choice of tick control method?

☐ Veterinarian

☐ Fellow dog owner

☐ Pet supply shopkeeper

☐ Personal research

☐ Other (Specify): ……………………….

33. How long have you been using this specific tick control method on your dog(s)?

☐ Less than 1 month

☐ 1-3 months

☐ 4-6 months

☐ 7-12 months

☐ More than 1 year

34. Where do you usually buy or get the products you use for tick control?

☐ At home

☐ At veterinary clinic

☐ Local pet shop

☐ Community animal care day

☐ Other (specify): …………………………….

35. Who usually applies the tick control products on to your dog(s)

☐ Veterinarian

☐ Household worker

☐ Pet supply shopkeeper

☐ I personally

☐ Other (Specify): ……………………….

36. Where do you usually apply or perform the tick control method from?

☐ At home

☐ At veterinary clinic

☐ Local pet shop

☐ Community animal care day

☐ Other (specify): …………………………

37. How do you determine it's time to treat your dog for ticks?

☐ On a regular schedule

☐ When I observe ticks

☐ After being advised

☐ Other (Specify): ………………………….

Section 5: Effectiveness of Tick Control Practices

38. How effective is your current tick control method?

☐ Very effective (ticks disappear for weeks/months)

☐ Somewhat effective (ticks return in a short time)

☐ Not effective (ticks remain despite treatment)

39. How long after applying or using the method chosen above do you typically observe its effect on ticks?

☐ immediate

☐ within a few hours

☐ a few days

☐ 1 week

40. How long does the treatment protect your dog before ticks reappear?

☐ Less than 1 week

☐ 1–2 weeks

☐ 2–4 weeks

☐ Over 1 month

41. Have you ever changed products/methods due to poor results?

☐ Yes (specify new method): ……………………….

☐ No

42. Have you observed acaricide failure (i.e., product no longer works)?

☐ Yes

☐ No

☐ Not sure

Section 6: Safety of Tick Control Practices

43. Have you or anyone in your household experienced health issues from applying tick control products?

    ☐ Yes

    ☐ No

44. If yes, which of the following side effects were experienced or observed? (Tick all that apply)

    ☐ Skin irritation

    ☐ Headache

    ☐ Breathing difficulty

    ☐ Dizziness

    ☐ No issues

    ☐ Other (specify): ……………………………….

45. Do you use protective gear (e.g., gloves, masks) while applying these products?

    ☐ Always

    ☐ Sometimes

    ☐ Never

46. If never, why?

    ……………………………………………………………………………………….

47. Are the instructions on the product clear and easy to follow?

    ☐ Yes

    ☐ No

48. Has your dog(s) ever suffered from any side effects of the chemical product being used?

    ☐ Yes

    ☐ No

49. If yes, which of the following side effects has your dog experienced? (select all that apply)

    ☐ Skin rashes or burns

    ☐ Vomiting

☐ Seizures

☐ Hair loss

☐ Weakness or lethargy

☐ Diarrhea

☐ Breathing issues

☐ No side effects observed

☐ Other (specify): ………………………

50. How would you rate the severity of these side effects?

☐ Mild (resolved on its own)

☐ Moderate (needed attention at home)

☐ Severe (required a vet visit)

51. Did stopping the use of the product reduce the effects?

☐ Yes

☐ No

☐ Not sure

52. Do you report these side effects to anyone?

☐ Yes

☐ No

53. If yes, to whom?

☐ Veterinarian

☐ Drug seller or retailer

☐ NDA

☐ MAAIF

☐ Other (specify): ………………………

Section 7: Disposal of Wastes from Tick Control Practices

54. How do you dispose of empty containers or leftover tick control products?

☐ Burning

☐ Burying

☐ Disposing in trash bin

☐ Reusing the container for other purposes (specify):

………………………………

☐ Pouring leftover chemical into the environment

☐ Other (specify): ……………………….

55. Are you aware that improper disposal of acaricides can harm the environment and public health?

☐ Yes

☐ No

56. Have you received any education or guidance on proper disposal of these products?

☐ Yes

☐ No

57. If yes, from whom?

………………………………………………………………………………………

Appendix III: Investigator's Check List

Name of the owner: …………………………………………… Q: Code 001

GPS Location: ………………………… Date: ……………………………

Section 1: Acaricide Details (To be completed for each acaricide product mentioned by the dog owner)

No.	Item to Check	Details (fill in / tick what applies)
1.	Brand name	
2.	Manufacturer	
3.	Country of origin	
4.	Active ingredients	
5.	API/ Concentration of the active ingredients	
6.	Quantity	
7.	Dose rate	
7.	Indication for use in dogs	☐ Yes ☐ No
8.	Extra-label use	☐ Yes ☐ No
9.	Storage conditions	(Tick all that applies)
		☐ cool and dry place ☐ out of direct sunlight ☐ out of reach of children and pets ☐ original container ☐ none of the above

Section 2: Kennel/Dog Environment Details (To be completed through observation)

No.	Item to Check	Details
1.	Kennel/Housing type	☐ Wooden ☐ Concrete ☐ wire mesh ☐ open yard ☐ other (specify); ……….
2.	Cleanliness of the kennel	☐ poor ☐ moderate ☐ good
3.	Presence of any crevices in the kennel	☐ Yes ☐ No

4.	Presence of any ticks in the kennel	☐ Yes	☐ No
5.	Presence of vegetation around Kennel/Housing	☐ Yes	☐ No
6.	Wild life or other animals in the vicinity	☐ Yes	☐ No

Investigator Notes:

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

Investigator Signature: ………………………………………………….

Appendix IV: Standard operating procedure for tick collection from dogs, preservation and storage

Purpose

The following procedure describes the steps that need to be undertaken to collect, preserve and store ticks.

Materials and equipment

Clinical coat, muzzle, dog catcher, pair of fine tweezers, gloves, marker pens, 15ml falcon tubes and ube holders, 70% Ethanol

Procedure

a. Tick collection

1. Prepare all materials needed.
2. wear your clinical coat.
3. Select one dog per household.
4. The dog owner restrains the dog or you help him restrain the dog.
5. observe from close range to the animal for any possible tick infestation, and then proceed to check the entire body of the dog for ticks.
6. Using a pair of fine tweezers, pick any observed ticks from only one half of the animal's body

b. Tick preservation

1. Place the collected ticks into a falcon tube containing 70% Ethanol
2. Label the sample appropriately

c. Tick storage

1. Store the collected ticks at room temperature

conclusion

Samples collected for laboratory analysis.

Appendix V: Standard operating procedure for data collection on tick control practices

Purpose

The following procedure describes the steps that need to be undertaken to collect data on tick control practices from dog owners.

Materials and Equipment

Consent forms, investigator's check list, pen, android mobile phone with a kobo collect tool application.

Procedure

1. Schedule appointments with the purposively selected dog owners from clients visiting Twiga Veterinary clinic and Entebbe Veterinary centre and those obtained through snowballing sampling technique.
2. Explain the contents of the consent form to the dog owners in the simplest way possible and then obtain consent to proceed with data collection.
3. Ask and probe for information regarding tick control on their dogs, explain the meaning of each question and the multiple-choice answers availed in the questionnaire.
4. Observe the environment and also request to review containers of the tick control products.

Conclusion

Data on tick control collected.

Appendix VI: Standard operating procedures for morphological identification of ticks

Purpose

The following procedure describes the steps that need to be undertaken to identify ticks morphologically in the laboratory.

Materials and Equipment

Pair of fine tweezers, fine brush, pen, note book, paper tissue, stereo microscope, marker pens

Procedure

1. Clean the ticks using a fine brush and a pair of fine tweezers
2. Leave the ticks to dry on paper tissue before viewing them under a stereo microscope
3. Identify the ticks to species level using keys provided by Matthysse & Colbo (1987) in comparison to those provided by Walker et al. (2003)

Conclusion

Ticks identified morphologically

Appendix VII: Pictorials

A B

C D

Images: A- Tick collection using a fine pair of tweezers, B- Looking for ticks on the sdog, C and D- morphological identification of ticks in RTC laboratory