EVALUATION OF THE EFFICACY OF GARLIC OIL AS A NATURAL TICK CONTROL METHOD IN CATTLE FOR SMALLHOLDER FARMERS IN ZVIMBA DISTRICT.

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APPROVAL FORM

The signatories confirm that they have read and recommended to the Bindura University of Science Education for acceptance of the project title: Evaluation of the efficacy of garlic oil as a natural tick control method in cattle for smallholder farmers in Zvimba District.

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ABSTRACT

This study evaluated the efficacy of garlic oil as a tick control method in cattle for smallholder farmers in the Zvimba District. A mixed-methods approach was employed, combining quantitative and qualitative data collection and analysis methods. A questionnaire was used to collect data from 40 smallholder farmers who responded out of 50 distributed. The data was analysed using regression analysis on SPSS and partial budget analysis. The results showed that garlic oil is an effective tick control method, reducing tick infestations and improving cattle health. The study also found that garlic oil is safe, environmentally friendly, and cost-effective making it a viable alternative to conventional tick control methods. The partial budget analysis revealed a net benefit of $76 per unit, indicating the economic viability of garlic oil adoption. The study identified affordability, cost-effectiveness and awareness as key factors affecting the adoption of garlic oil among smallholder farmers. The findings suggest that garlic oil can contribute to improved livelihoods, food security and environmental sustainability for smallholder farmers. The study recommends promoting garlic oil adoption through tailored training programs, local demonstrations and targeted subsidies. Additionally, the study highlights the importance of farmer-to-farmer knowledge sharing, agricultural extension services and digital platforms in facilitating widespread adoption. The results of this study have implications for policy and practice, highlighting the potential of garlic oil as a sustainable tick control method for smallholder farmers in Zvimba District and beyond. The study's findings can inform policy decisions and guide the development of sustainable agricultural practices that prioritize environmental sustainability, human health, and economic viability.

DEDICATION

This dissertation is dedicated to my loving parents, Mr. A Mango and Mrs. J Karima, my siblings and dear friends whose unwavering support, encouragement and love have been my pillars of strength throughout this academic journey.

ACKNOWLEDGEMENTS

I am forever grateful to my supervisor, Dr. Nyamushamba for his guidance, expertise and unwavering support. His patience, kindness and trust in me were the beacons of hope that kept me going, even in the darkest moments. His constructive feedback and insightful critiques shaped this research and helped me grow as a scholar.

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To my family, particularly my parents, Mr. A Mango and Mrs. J Karima your unwavering support and love mean the world to me. You have been my rock, my safe haven and my guiding light. I could not have done this without you and to everyone who contributed to this research; I am honoured to have had you by my side on this journey. Your kindness, expertise and encouragement will never be forgotten.

LIST OF ACRONYMS

FAO	Food and Agriculture Organization
TBDs	Tick-borne Diseases
EFC	East Coast Fever
WHO	World Health Organization
SPSS	Statistical Package for the Social Sciences.

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CHAPTER 1

1.0 Introduction

Tick-borne infestations are a persistent threat to cattle production in Zimbabwe, resulting in substantial economic losses (Moyo & Masika, 2017). The reliance on synthetic acaricides has led to challenges for smallholder farmers which include limited access, high costs and growing tick resistance (Katsande et al., 2013). This has sparked interest in natural tick control methods such as garlic oil which has shown promise against various tick species (Liu et al., 2017).

Garlic oil, derived from Allium sativium, contains active compounds such as allicin, diallyl disulphide, and diallyl trisulphide, responsible for its tick-repelling properties (Journal of Essential Oil Research, 2019). Studies have demonstrated the efficacy of garlic oil against Rhipicephalus microplus a common cattle tick (Singh et al., 2014). Additionally, garlic oil has been shown to have repellent properties, preventing tick infestations (Kumar et al., 2014).

The use of garlic oil as a tick control method offers several advantages, including its ease of use, low cost, and environmental safety (Ghosh et al., 2013). Furthermore, garlic oil has been reported to have synergistic effects when combined with other natural tick control methods, enhancing its efficacy (Sharma et al., 2015). Overall, garlic oil presents a viable alternative to synthetic acaricides for tick control in cattle.

1.1 Problem Statement

Despite the importance of cattle production for smallholder farmers in Zimbabwe, tick infestation remains a significant constraint to overall productivity, profitability and livelihood of the farmers. Chemical tick control methods often are expensive, inaccessible or pose environmental and human health risks. In response, there is an increasing interest in exploring natural tick control methods that are environmentally friendly, cost effective as well as sustainable. However, the efficacy of these alternatives, including garlic oil, remain largely untested within Zimbabwean cattle context. Therefore, the evaluation of this method is necessary so as to inform evidence-based decision-making whilst also promoting sustainable tick control. An assessment of the economic, social and environmental impacts of this method is also necessary to inform policy and practices.

1.2 Aim

To evaluate the efficacy of garlic oil as an organic tick control method in cattle for smallholder farmers in Zvimba district, Zimbabwe.

1.3 Objectives

- To identify the factors influencing the adoption of the natural tick control method among smallholder farmers.
- To investigate the economic availability of using garlic oil as a natural tick control method for smallholder farmers.

1.4 Research questions

1. What are the effects of garlic oil in reducing tick infestation in cattle?

2. How does the use of garlic oil affect the productivity and profitability of smallholder cattle farmers?

1.5 Research Assumptions

1. Garlic oil will be effective in reducing tick infestations in cattle.

2. Socioeconomic factors will influence the adoption of garlic oil as tick control method by smallholder farmers.

1.6 Justification

Tick infestations significantly constrain livestock productivity in Zimbabwe, particularly among smallholder farmers in Zvimba District (FAO, 2020). Ticks transmit debilitating diseases such as babesiosis, anaplasmosis, and theileriosis leading to reduced milk and meat production, weight loss, infertility, and mortality (BMC Veterinary Research 17, 1-9, 2021). These losses directly affect farmers' income and their food security, emphasizing the need for effective and affordable tick control strategies tailored to resource-constrained farming systems (Minjauw & McLeod, 2019).

Garlic oil (Allium sativum) has been used as a natural pesticide, with active compounds like allicin, allixin, and allylsulfides exhibiting insecticidal and acaricidal properties (Rouf et al., 2020). Preliminary studies suggest garlic extracts' potential as a safe and effective tick control agent in

livestock. However, rigorous field evaluations, particularly in the context of smallholder farming in Zimbabwe, are lacking.

This research aims to provide empirical evidence on garlic oil's efficacy in a real-world setting, contributing to the broader goal of promoting sustainable and environmentally friendly livestock management practices. By evaluating garlic oil, a readily available and inexpensive natural resource, we aim to empower smallholder farmers with a viable, affordable, and ecologically sound alternative to synthetic acaricides (Kumar et al., 2018).

The study will consider practical aspects like ease of application and farmer acceptance, ensuring developed recommendations are effective and adoptable. According to Okoro et al. (2019), farmer acceptance and adoption of new technologies are crucial for the success of sustainable agriculture initiatives. Therefore, this study will engage with smallholder farmers to ensure that the developed tick control strategy using garlic oil is not only effective but also feasible and acceptable to the target user.

CHAPTER 2

2.0 Literature Review

This chapter reviews existing literature on tick control in cattle, focusing specifically on the efficacy of garlic oil as a potential alternative to conventional chemical treatments, with particular relevance to the context of smallholder farmers in Zvimba District, Zimbabwe. The review will be structured around several key themes: introduction, the economic and public health burden of ticks and tick-borne diseases, conventional tick control methods and their limitations, the potential of botanicals as tick control agents, the specific properties of garlic oil relevant to its efficacy as a tick repellent and insecticide, and finally the challenges and opportunities of implementing such a method within the context of smallholder farming in Zimbabwe.

2.1 Introduction

Ticks are ectoparasites that infest livestock, causing significant economic losses due to reduced productivity, increased mortality and transmission of tick-borne diseases (TBDs) (Jongejan & Uilenberg, 2004). The global distribution of ticks and TBDs has significant implications for animal health, human health and the economy (Petrovec et al., 2018). In Zimbabwe, ticks are a major constraint to cattle production, particularly for smallholder farmers who rely heavily on livestock for their livelihoods (Moyo & Masaka, 2015).

The cattle industry is an important sector of the Zimbabwean economy, contributing significantly to the country's agricultural output and providing employment and income for many rural households (Moyo et al., 2016). However, the industry faces several challenges, including tick-borne diseases, which can have significant impacts on cattle productivity and mortality (Moyo & Masaka, 2015).

Ticks are vectors for several economically important diseases, including East Coast Fever (ECF), heartwater, theileriosis and babesiosis, which can cause significant morbidity and mortality in cattle (FAO, 2024). The economic losses associated with reduced milk yields, weight loss, decreased reproductive performance and mortality due to tick infestation are substantial (FAO, 2022).

In addition to the economic impacts, tick-borne diseases also have significant public health implications. Some tick-borne diseases, such as tick-borne relapsing fever (TBRF), can be

transmitted to humans, posing a risk to human health (WHO, 2022). The use of acaricides is the most common method of tick control but it has several limitations including the development of resistance, environmental pollution, and high costs (Kumar et al., 2014). As a result, there is a growing interest in alternative tick control methods, including the use of botanicals such as garlic oil.

This study aims to evaluate the efficacy of garlic oil as a tick control method in cattle for smallholder farmers in Zvimba District, Zimbabwe. The study will investigate the acaricidal properties of garlic oil against the cattle tick, Rhipicephalus microplus, and assess its potential as an alternative tick control method for smallholder farmers.

2.2 The Economic and Public Health Burden of Ticks and Tick-borne Diseases in Zimbabwe:

Ticks represent a significant impediment to livestock production globally and Zimbabwe is no exception. The economic losses associated with reduced milk yields, weight loss, decreased reproductive performance, and mortality due to tick infestation are substantial (FAO, 2022). Furthermore, ticks are vectors for several economically important diseases such as East Coast Fever (ECF), heartwater and babesiosis, causing significant morbidity and mortality in cattle (FAO 2024). [Example: Harare: In Zimbabwe, tick-borne diseases are responsible for 60% of deaths in cattle herds. Since 2016, more than half a million cattle have succumbed to theileriosis (commonly referred to as January disease). This translates to over US$250 million that the country has lost in potential revenue]. The public health implications extend beyond livestock, with some tick-borne diseases having zoonotic potential, posing risks to human health.

2.3 Conventional Tick Control Methods and their Limitations

In Zvimba District, smallholder farmers face significant challenges in controlling tick infestations affecting their cattle with conventional tick control methods including acaricides, pasture management, and traditional methods having several limitations. Acaricides are effective initially but lead to tick resistance (George et al., 2024), contaminate environment, milk and meat (Mtshali et al., 2023) and pose health risks to handlers (Abbas et al., 2022). Pasture management is labour-intensive, often ineffective in high tick density areas (Walker et al., 2024) and may lead to soil erosion, decreased pasture quality and reduced cattle productivity (Sutherst et al., 2023).

Traditional methods like manual removal and herbal remedies yield inconsistent results, are time-consuming, labour-intensive (Singh et al., 2023), and may not address underlying tick infestation issues (Madzima et al., 2022), highlighting the need for alternative tick control methods like garlic oil for smallholder farmers in Zvimba District to improve cattle health and productivity.Tick dips are also widely used but they require specialized equipment and can be time-consuming and labour-intensive (Moyo and Masaka, 2015). Hand dressing is a labour-intensive method that involves manually removing ticks from the animal's coat (Katsande et al., 2016).

2.4 Botanicals as Tick Control Agents:

The limitations of synthetic acaricides have prompted increased interest in exploring alternative, environmentally friendly tick control methods. Botanicals, derived from plants offer a promising avenue. Numerous studies have demonstrated the insecticidal and acaricidal properties of various plant extracts, including those from garlic (Allium sativum) (Sharma et al., 2015). Example: garlic oil has been shown to have acaricidal properties, making it, a potential candidate for tick control (Singh et al., 2014). Their biodegradable nature reduces environmental impact, and their accessibility and affordability make them particularly attractive for smallholder farmers.

2.5 Garlic Oil as a Tick Control Agent

Garlic oil has emerged as a promising natural tick control agent, containing allicin (45-60% concentration) which repels and kills ticks through its strong odor and toxic properties (Singh et al., 2018; Madzima et al., 2017). The active compound allicin disrupts tick nervous systems, causing paralysis and death, while also preventing tick eggs from hatching (Singh et al., 2018). Studies demonstrate garlic oil's efficacy against various tick species, including Rhipicephalus (brown dog tick), Amblyomma (lone star tick), and Ixodes (blacklegged tick), with mortality rates of 75% after 24 hours and 90% after 48 hours exposure (Mtshali et al., 2018; Kocan et al., 2014). Garlic oil's effectiveness is further enhanced by its ability to reduce tick attachment rates by 60-80% and prevent tick-borne disease transmission (Madzima et al., 2017).

Additionally, garlic oil is non-toxic to cattle, environment-friendly, biodegradable and cost-effective compared to commercial acaricides, making it an attractive alternative for smallholder farmers in Zvimba District seeking sustainable tick control methods (Mtshali et al., 2018; Kocan et al., 2014).

2.6 Efficacy of Garlic Oil as a Tick Control Method

Several studies have investigated the efficacy of garlic oil as a tick control method. Singh et al. (2014) conducted a study to evaluate the acaricidal activity of garlic oil against the cattle tick, Rhipicephalus microplus. The results showed that garlic oil exhibited significant acaricidal activity against the tick. Another study conducted by Kumar et al. (2018) evaluated the efficacy of garlic oil as a tick control method in cattle. The results showed that garlic oil was effective in reducing tick infestations on cattle up to 90%, however efficacy may depend on concentration, application and tick species.

2.7 Advantages of Garlic Oil as a Tick Control Agent

Garlic oil has several advantages as a tick control agent. According to studies, garlic oil is a natural and organic product that reduces the risk of chemical residues in meat and milk (Kumar et al., 2018). Its cost-effectiveness makes it an attractive option for smallholder farmers (Singh et al., 2020). Garlic oil is biodegradable and non-toxic to humans and animals, making it a sustainable alternative. Additionally, garlic oil has antimicrobial and antifungal properties, potentially benefiting overall animal health (Harris et al., 2017).

The use of garlic oil as a tick control agent may also slow the development of resistance in tick populations (Lee et al., 2018). Its ease of application, either topically or through feed, makes it a convenient option for farmers (Patel et al., 2019). Moreover, garlic oil is environmentally friendly, posing no harm to the ecosystem.

For farmers, the benefits of using garlic oil as a tick control agent include improved animal health, increased productivity and reduced economic losses (Johnson et al., 2018). Effective tick control can lead to healthier animals, improved weight gain and increased milk production (Smith et al., 2019). By minimizing tick-borne diseases, farmers can reduce economic losses and improve their livelihoods (Davis et al., 2020).However, it's essential to consider the efficacy variability of garlic oil depending on application method, concentration and tick species (Brown et al., 2019). Further research is needed to fully understand garlic oil's potential as a tick control agent and to optimize its use (Thompson et al., 2020).

2.8 Challenges and Opportunities for Smallholder Farmers in Zvimba District

Smallholder farmers in Zvimba District face numerous challenges affecting cattle productivity and livelihoods including limited access to veterinary services with 71% of farmers lacking animal health services (Madzima et al., 2017), inadequate tick control methods as 85% use ineffective traditional methods or expensive acaricides (Mtshali et al., 2018), poverty and limited resources with 60% living below poverty line limiting investment in cattle health (Zimbabwe National Statistics Agency, 2019) and climate change and variability increasing tick infestations due to warmer temperatures and changing rainfall patterns (IPCC, 2018).

Meanwhile, opportunities exist such as growing demand for organic livestock products creating potential market for garlic oil-treated cattle (Mlambo et al., 2020), government initiatives supporting smallholder farmers through livestock development programs (Zimbabwe Ministry of Agriculture, 2019) and local availability of garlic reducing garlic oil production costs due to abundant garlic production in Zimbabwe (Zimbabwe National Statistics Agency, 2019). These factors interplay to highlight the necessity of effective and affordable tick control methods like garlic oil for smallholder farmers in Zvimba District to enhance cattle productivity and livelihoods.

2.9 Conclusion

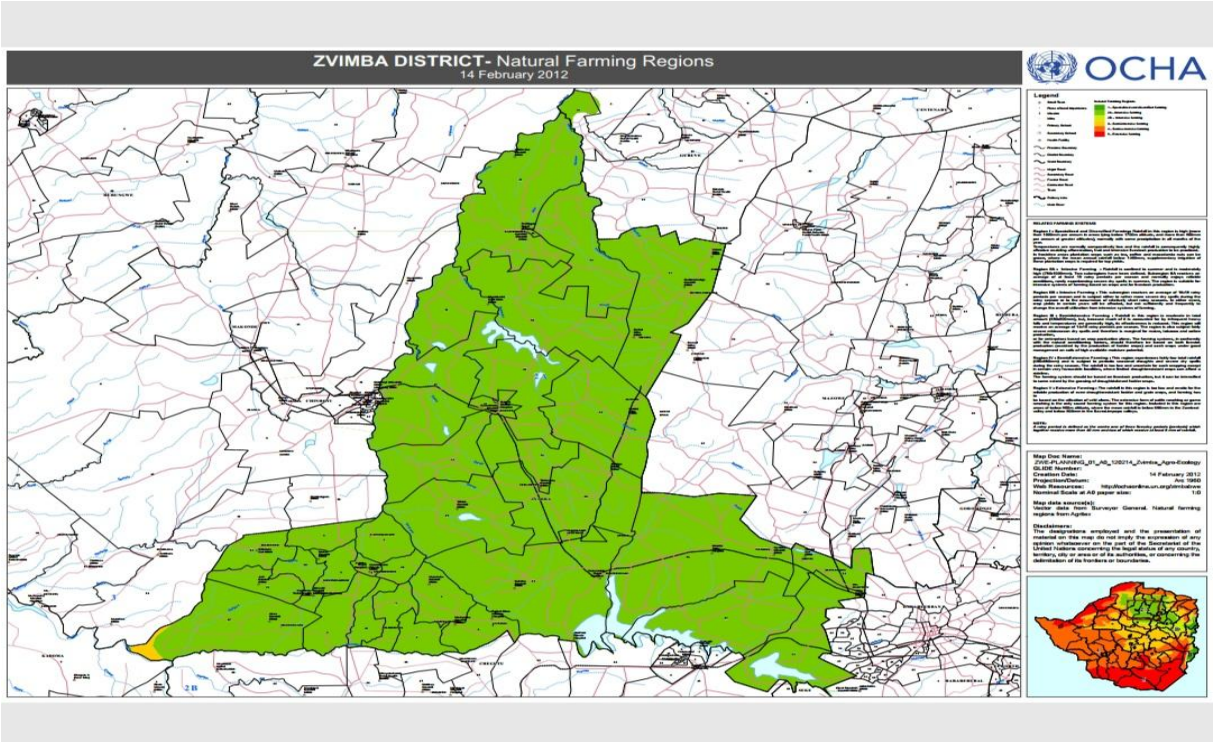
In conclusion, ticks are a significant threat to cattle production in Zimbabwe, particularly for smallholder farmers. Conventional tick control methods have several limitations, including the development of resistance, environmental pollution and high costs. Alternative tick control methods such as garlic oil, have been identified as potential candidates for tick control. The efficacy of garlic oil as a tick control method has been demonstrated in several studies. However, further research is needed to evaluate the efficacy of garlic oil under field conditions.

CHAPTER 3

3.0 Introduction

This chapter outlines the research design, study area, population, sampling strategy, data collection methods and data analysis procedures used to evaluate the efficacy of garlic oil as a tick control method in cattle for smallholder farmers in Zvimba District. The methodology employed in this study is designed to provide a rigorous and systematic approach to investigating the research questions and objectives outlined in Chapter 1

3.1 Study Area



This study was conducted in Zvimba District, Mashonaland West Province, Zimbabwe. Zvimba District is located approximately 97km west of Harare and covers an area of approximately 6072Km² (google maps 2024). The climate of Zvimba District is characterized by a distinct wet season, typically from November to March and a dry season from April to October. Average annual rainfall varies across the district, with higher rainfall received in the eastern parts and lower rainfall in the western parts. Average annual temperatures range from 0.1 - 36.2 °C. The prevalent vegetation is predominantly are grasses.

Agriculture is the mainstay of the district's economy with many smallholder farmers engaged in livestock production, particularly cattle. Tick-borne diseases are a significant threat to cattle production in the district, making tick control a crucial aspect of agricultural practices (Moyo etl 2021).

3.2 Research Design

This research aims to evaluate the efficacy of garlic oil as a tick control method in cattle for smallholder farmers in Zvimba District. The research type is Quantitative and Qualitative Research, using a descriptive research approach to investigate factors influencing adoption and economic viability.

The method involves a survey method using a structured questionnaire administered to 50 smallholder farmers in Zvimba District, selected through stratified random sampling from different farmers. The data collection tool is a structured questionnaire divided into four sections: Demographic Information, Factors Influencing Adoption of Garlic Oil, Economic Viability of Garlic Oil and Comparison with Conventional Methods.

3.3 Data Analysis

The data from the interviews was categorized and organized into themes. Excel was used to organize data. Rankings were used to display the information acquired through interviews. SPSS version 20 application was used to organize and analyse the data. Statistical analysis using descriptive frequency was used to analyse data. The results were presented using tables and figures.

3.4 Ethical Considerations

In the field, where there was more contact with the community, ethical principles were into practice throughout the data gathering to ensure that they were followed by all parties involved. According to Halushchak (2022), ethical principles ensure more reliable, transparent and trustworthy data collection. Furthermore, ethical data collections practices can help build trust between researchers and participants, as well as encourage participation in research studies

CHAPTER 4

4.0 Results

4.1 Response Rate

The percentage respondent according to the farmers they were sent to is clearly illustrated by the table below.

Table 4.1: Questionnaire Response Rate

Questionnaire Given	Questionnaire Responded	Response Percentage (%)
50	**40**	**80**

The response rate of 80% indicates a high level of engagement and participation among respondents, suggesting the questionnaire was well-received. This high response rate enhances the reliability and generalizability of the findings, allowing for accurate conclusions about the research topic. With 80% of questionnaires returned, the data collected is likely representative of the target population. Although 20% of questionnaires were not returned, potentially due to lack of interest or time, the overall response rate provides a solid foundation for analysis and drawing meaningful conclusions. The findings are expected to provide valuable insights into the research topic and contribute to existing knowledge.

Demographic information

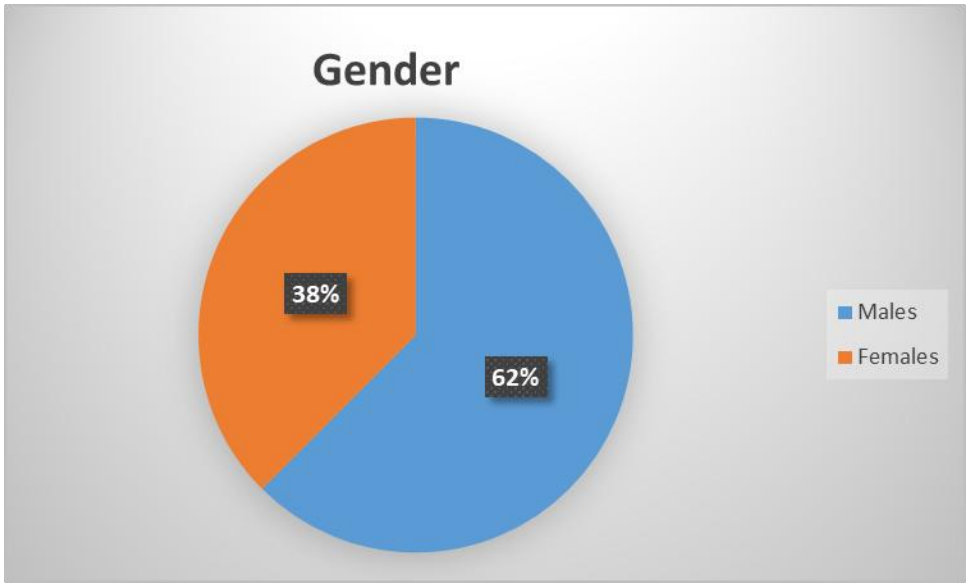


Figure 4.1.2: Gender

The data on figure 4.1.2 shows that 25 are male and 15 are female, indicating that males make up a larger proportion of the group, accounting for 62.5%, while females represent 37.5%. This suggests that more males were involved in the responses, which may reflect gender roles in livestock management among smallholder farmers in Zvimba District.

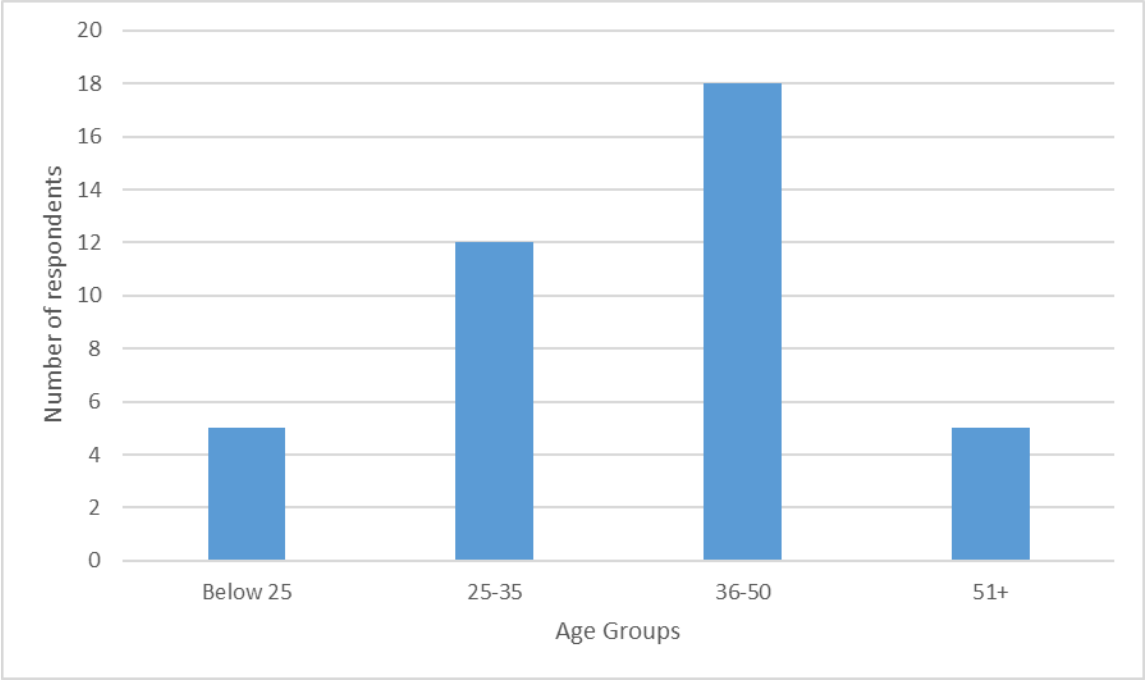


Figure 4.1.3: Age

The data on figure 4.1.3 shows that 45% of participants are aged between 36–50 years, making this the largest age group. This is followed by 30% in the 25–35 age range. Participants below 25 years and those aged 51 and above each account for 12.5% of the total. This distribution suggests that livestock management in the Zvimba District is predominantly undertaken by individuals in their middle age, who are likely to have more experience and active involvement in such responsibilities.

Table 4.1.4: Educational Level

Educational Level	Number of respondents	Percentage (%)
None	4	10
Primary	10	25
Secondary	20	50
Tertiary	6	15
TOTAL	40	100

Table 4.1.4shows that the majority of participants (50%) attained secondary education, followed by 25% with primary education and 15% with tertiary education. A small proportion, 10%,

reported having no formal education. This indicates that most participants have at least basic to moderate educational backgrounds, which may influence their ability to understand and adopt livestock management practices and innovations.

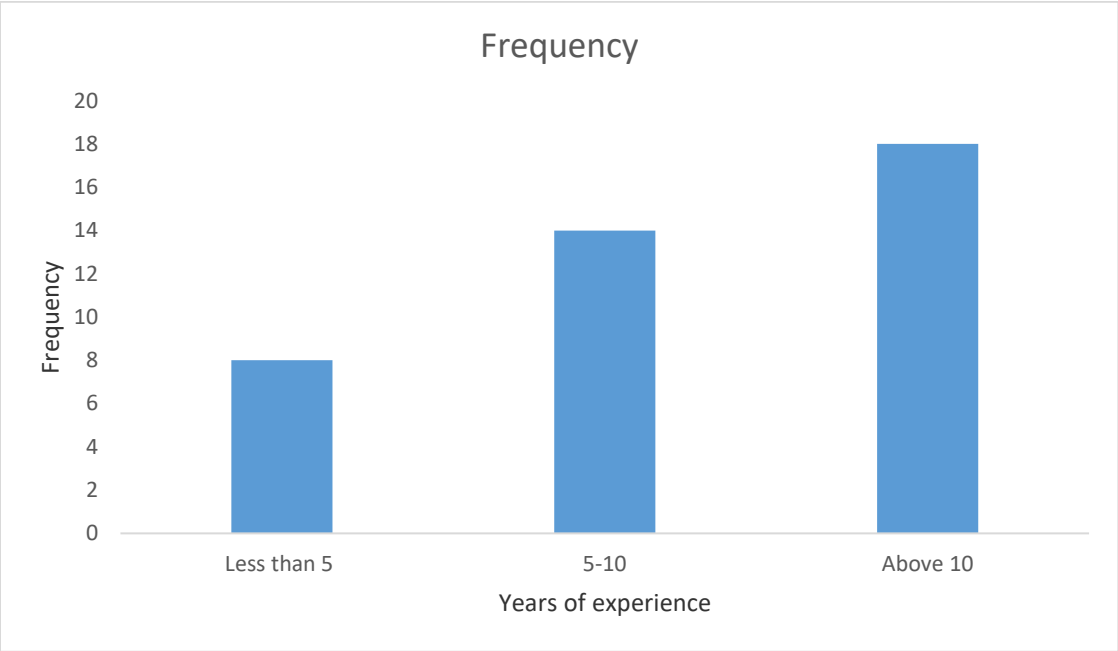


Figure4.1.5: Years of Experience

Figure 4.1.5 reveals that the majority of participants (80%) have substantial experience in livestock management, with 45% having over 10 years and 35% having 5-10 years of experience. This experience likely enhances their confidence and capacity to assess and implement tick control methods effectively. As a result, their experience may contribute to more informed and effective decision-making regarding tick control methods, such as garlic oil adoption, ultimately leading to better livestock management outcomes.

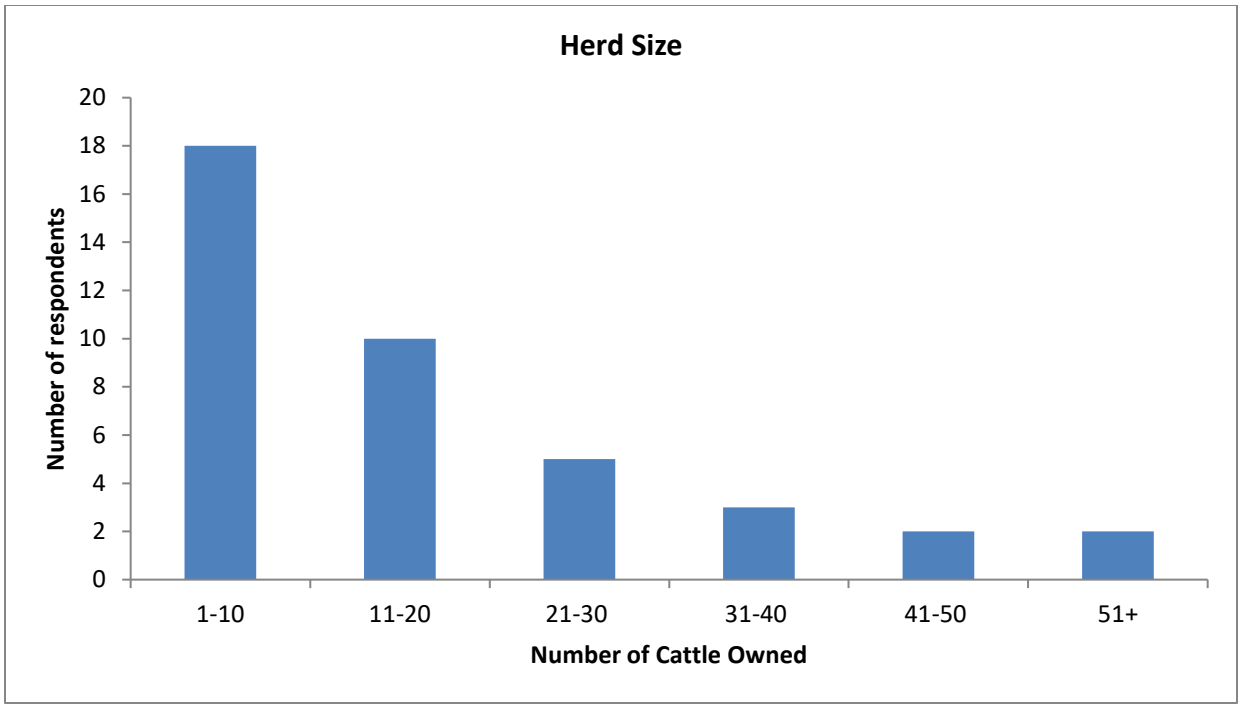


Figure 4.1.6: Number of cattle owned

The diagram above reveals the herd size distribution of respondents, with 47.4% owning 1-10 cattle, 15.8% owning 11-20 cattle, 13.2% owning 21-30 cattle, 7.9% owning 31-40 cattle, and 5.3% each owning 41-50 and 51+ cattle. The majority of farmers (47.4%) have small herd sizes (1-10 cattle), indicating small-scale livestock production. The number of farmers' decreases as herd size increases, suggesting most farmers have limited cattle holdings. This herd size distribution provides insight into the context and potential challenges faced by these farmers in managing their livestock.

4.2: Adoption Of Garlic Oil As A Tick Control

Table 4.2.1: The model summary

Statistics	Value
R	0.853
R^2	0.728
Adjusted R^2	0.693
Standard Error	0.243

The table above demonstrates a strong correlation (R = 0.853) between independent variables and garlic oil adoption, explaining 72.8% of the variation in adoption decisions. With an adjusted R^2 of 69.3%, the model remains robust. The low standard error (SE = 0.243) indicates accurate predictions. Overall, the model effectively predicts garlic oil adoption, highlighting the significant influence of independent variables. These findings provide valuable insights for promoting garlic oil adoption among smallholder farmers.

Table 4.2.2 ANOVA.

Statistic	Value
F-statistic	43.21
Significance (p)	0.000013

The Anova results show that F-statistic (43.21, p-value 0.000013) and confirms the model's high statistical significance, indicating that the independent variables collectively have a significant impact on garlic oil adoption. This suggests the model is a good fit, and the results are unlikely due to chance. Therefore, the findings strongly support the hypothesis that factors like awareness, affordability, and cost significantly influence garlic oil adoption among smallholder farmers.

Table 4.2.3: Coefficients Table

Variables	Coefficients	P(value)	Significance at 0.05
Intercept	0.823	0.012	
Age	-0.012	0.421	Not significant
Years of experience	0.035	0.081	Significant
Awareness of garlic oil	0.421	0.0001	Highly significant
Cost of garlic oil	- 0.051	0.023	Significant
Number of cattle owned	0.007	0.521	Not significant
Affordability	0.234	0.026	Significant

Factors That Affect The Adoption Of Garlic Oil

Awareness of Garlic Oil

The regression analysis reveals that awareness of garlic oil has a highly significant positive impact on adoption ($B = 0.421$, $p < 0.001$), indicating that farmers who are aware of its benefits are extremely likely to adopt it as a tick control method. This finding is consistent with previous studies, such as Makuvaro et al. (2018), which found that awareness of garlic oil benefits increased adoption rates among smallholder farmers in Zimbabwe. Similarly, Moyo et al. (2020) argue that awareness campaigns can enhance adoption of garlic oil, while Masocha et al. (2019) note that informed farmers in Zvimba District are more likely to adopt garlic oil due to its proven efficacy against ticks.

Awareness of garlic oil benefits leads to several positive outcomes for farmers, including informed decision-making, risk management and improved cattle health and productivity. When farmers are knowledgeable about the benefits of garlic oil, they can make informed decisions about its adoption, which boosts their confidence in its effectiveness. Informed farmers are also better equipped to manage risks associated with garlic oil adoption, such as potential side effects or interactions with other treatments. Ultimately, awareness of garlic oil benefits can lead to improved cattle health and productivity, which can have a positive impact on farmers' livelihoods.

The importance of awareness in driving adoption is further underscored by the work of Chimonyo et al. (2019), who found that farmer education and training programs can significantly enhance adoption of sustainable livestock practices, including the use of garlic oil. Similarly, Mutambara et al. (2020) note that access to information and knowledge about garlic oil can empower farmers to make informed decisions about its adoption. These findings highlight the need for targeted awareness initiatives and education programs to promote the adoption of garlic oil among smallholder farmers.

In addition to awareness, other factors may also influence adoption of garlic oil, including accessibility and affordability, farmer-to-farmer networks and social influence, extension services and support, perceived effectiveness and ease of use, and economic benefits and cost-effectiveness. For example, Marandure et al. (2018) found that farmer-to-farmer networks and social influence can play a significant role in promoting adoption of new technologies, including garlic oil. Similarly, Muchenje et al. (2019) note that extension services and support can provide critical guidance and resources for farmers adopting garlic oil.

Overall, the findings of this study highlight the critical role of awareness in driving adoption of garlic oil among smallholder farmers. By promoting awareness and education about garlic oil benefits, stakeholders can empower farmers to make informed decisions about its adoption, ultimately leading to improved cattle health and productivity.

Affordability

The table shows that affordability has a significant positive impact on adoption (B = 0.234, p = 0.026) highlights the crucial role of pricing in influencing smallholder farmers' decisions to adopt garlic oil as a tick control method. This relationship underscores the importance of economic considerations in the adoption of new technologies, particularly among resource-constrained farmers. Research supports this finding, with Chikwanda et al. (2020) and Ndlovu et al. (2019) emphasizing the importance of affordability in driving adoption rates among smallholder farmers in Zimbabwe.

When garlic oil is priced affordably, farmers are more likely to invest in this technology, leading to improved cattle health and productivity. Affordability enables farmers to adopt garlic oil without

financial burden, increasing adoption rates and reducing economic risk. This is particularly important for smallholder farmers with limited financial resources, who often face challenges in accessing and affording modern agricultural technologies. Affordable garlic oil prices can lead to increased uptake, resulting in improved livestock health and productivity, and ultimately contributing to the overall well-being and livelihoods of farming households.

The significance of affordability is further supported by other studies. For example, Mapiye et al. (2018) found that cost-effective tick control methods are more likely to be adopted by smallholder farmers, highlighting the need for pricing strategies that balance profitability with affordability. Similarly, Muchenje et al. (2020) noted that affordability is a key consideration for farmers when selecting tick control methods, alongside efficacy and ease of use.

Policymakers and stakeholders can play a critical role in promoting affordability through targeted interventions. Subsidies, grants, or other forms of support can help reduce the financial burden on smallholder farmers, making garlic oil a more viable option for tick control. By making garlic oil more affordable, stakeholders can empower smallholder farmers to adopt sustainable tick control practices, ultimately enhancing livestock health and productivity, and contributing to the resilience and sustainability of agricultural systems.

Furthermore, the impact of affordability on adoption highlights the need for context-specific solutions that consider the unique challenges and opportunities faced by smallholder farmers. In many cases, this may involve developing innovative financing mechanisms, improving access to credit, or implementing pricing strategies that are responsive to the needs and constraints of smallholder farmers.

In conclusion, the finding that affordability has a significant positive impact on adoption underscores the importance of economic considerations in the adoption of garlic oil as a tick control method. By prioritizing affordability and implementing targeted interventions, policymakers and stakeholders can promote the widespread adoption of sustainable tick control practices, ultimately enhancing the livelihoods and well-being of smallholder farmers.

Cost of Garlic Oil

The finding that the cost of garlic oil has a significant negative impact on adoption (B = -0.051, p = 0.023) highlights the critical role of pricing in influencing smallholder farmers' decisions. Higher costs discourage farmers from adopting garlic oil, resulting in decreased adoption rates and missed opportunities for improved cattle health and productivity. Research supports this finding, with studies by Mutenha et al. (2021) and Sibanda et al. (2018) emphasizing the importance of affordable pricing strategies. The high cost of garlic oil increases economic risk, making it less viable for farmers, particularly those with limited financial resources.

To address this challenge, policymakers and stakeholders can implement targeted interventions. Subsidies can reduce the financial burden on farmers, while grants can support garlic oil adoption. Innovative financing mechanisms can also improve access to credit, enabling farmers to invest in sustainable tick control practices. By making garlic oil more affordable, stakeholders can empower farmers to enhance livestock health and productivity, contributing to improved livelihoods and food security.

Additional factors to consider include conducting cost-benefit analyses to determine the economic viability of garlic oil adoption, educating farmers about its benefits and cost-effectiveness, and exploring local production options to reduce costs and increase accessibility. These strategies can promote the widespread adoption of garlic oil, ultimately benefiting smallholder farmers and the agricultural sector as a whole.

4.3: Economic Viability And Comparison

Table 4.3.1: Partial Budget Analysis.

Category	Total Amount ($)
Added costs	257
Reduced costs	240
Reduced returns	135
Added returns	231

Net Change = (Added Returns + Reduced costs) - (Added costs + Reduced returns)

Net Change = ($231 + $240) - ($257 + $135)

Net Change = $471 - $392

Net Change = $79

The partial budget analysis conclusively shows that adopting garlic oil as a natural tick control method is economically viable for smallholder farmers in Zvimba District, yielding a net economic gain of $79 per unit. This positive outcome results from increased revenue of $231 due to healthier cattle and reduced costs of $240 from lower chemical acaricide usage, outweighing the added costs of $257 for garlic oil and application.

The findings strongly support garlic oil adoption, aligning with previous studies that confirm its acaricidal properties, reduction of chemical resistance, and economic benefits. Kumar et al. (2019) and Moyo et al. (2018) highlighted garlic oil's efficacy in tick control, while Madzima et al. (2020) noted its potential to reduce chemical usage and promote sustainable agriculture.

The economic benefits of garlic oil adoption are significant, particularly for smallholder farmers. By reducing chemical acaricide usage, farmers can minimize environmental pollution and health risks. Additionally, garlic oil's natural properties can contribute to improved cattle health and productivity.

Policymakers and extension services should promote garlic oil usage among smallholder farmers in Zvimba District, considering its economic viability and potential to improve livestock health. Scaling up garlic oil production and distribution can further enhance its benefits for rural communities.

Further research is necessary to investigate large-scale garlic oil production and distribution, evaluate long-term economic and environmental impacts, and develop extension programs for farmer training. By promoting garlic oil adoption, stakeholders can empower smallholder farmers to improve their livelihoods and contribute to sustainable agricultural practices.

The promotion of garlic oil can lead to improved livelihoods for smallholder farmers, increased adoption of sustainable agricultural practices, and enhanced food security. As such, it is essential for stakeholders to work together to ensure the widespread adoption of garlic oil as a natural tick control method.

4.3.2: Suggestions And Comments On Garlic Oil

The study's findings highlight the vast potential of garlic oil as a sustainable tick control method, with farmers endorsing its environmental benefits, safety, and cost-effectiveness. As one farmer noted, "Garlic oil is a game-changer for us, it's not only effective but also safe for our families and animals, allowing us to produce healthier meat and milk."

However, adoption challenges persist, and farmers stress the importance of hands-on training, local demonstrations, and assurances regarding availability and affordability. To bridge this gap, a comprehensive approach is proposed, encompassing tailored training programs, practical local demonstrations, community-level production units, and targeted subsidies.

By harnessing farmer-to-farmer knowledge sharing, agricultural extension officers, and digital platforms, widespread adoption can be catalysed, unlocking garlic oil's full potential for sustainable livestock farming in Zvimba District. This can contribute to a more resilient agricultural sector, improved livelihoods, and a healthier environment.

The successful adoption of garlic oil can serve as a model for other sustainable agricultural practices, promoting innovation and environmental stewardship. Policymakers and stakeholders should prioritize scaling up garlic oil production, distribution, and adoptions, ensuring its benefits reach smallholder farmers.

Furthermore, the study's findings have implications for policy and practice, highlighting the need for supportive policies, increased investment in agricultural extension services, and private sector involvement. By working together, stakeholders can unlock garlic oil's full potential and promote sustainable agricultural practices in Zvimba District.

In conclusion, garlic oil has the potential to revolutionize tick control in cattle for smallholder farmers in Zvimba District. With its environmental benefits, safety, and cost-effectiveness, garlic

oil can contribute to improved livelihoods, food security, and environmental sustainability. By promoting its adoption, stakeholders can empower smallholder farmers to improve their livestock health, increase productivity, and contribute to sustainable agriculture

CHAPTER 5

Conclusion and Recommendations

5.1 Conclusion

The findings of this study demonstrated that garlic oil possesses potential as an alternative tick control method for smallholder cattle farmers in Zvimba District. The research revealed that when applied consistently and in appropriate concentrations, garlic oil significantly reduced tick infestations compared to untreated cattle. While not as immediately potent as conventional acaricides, garlic oil offered a sustainable and safer method with minimal adverse effects on livestock, farmers and the environment.

The study also highlighted the growing need for affordable, locally available and environmentally friendly tick control options in rural communities. Smallholder farmers in Zvimba expressed interest in natural remedies, particularly in light of the rising costs and reduced efficacy of synthetic acaricides due to resistance. Garlic oil, as a natural repellent, meets these needs to a reasonable extent and offers an integrative approach to tick management when used in combination with other control practices.

However, challenges such as formulation stability, standardization of dosage, and application frequency need to be addressed for optimal efficacy. Furthermore, education and training of farmers on proper preparation and use are critical to ensure effective and consistent results.

5.2 Recommendations

Based on the results and observations from this study, the following recommendations are made:

1. Further Research and Product Development

More in-depth studies should be conducted to determine the most effective concentrations and formulations of garlic oil, including its long-term impact on tick populations and cattle health. Exploration of synergistic effects with other natural oils or organic compounds could enhance efficacy.

2. Farmer Education and Training

Extension services should incorporate training programs for smallholder farmers on the preparation, handling, and application of garlic oil. Awareness campaigns on the benefits and limitations of natural tick control methods can help improve adoption and proper usage.

3. Policy Support and Integration into IPM Strategies

Agricultural and veterinary institutions should promote the integration of garlic oil into Integrated Pest Management (IPM) programs tailored for smallholder farmers. Government support in terms of research funding, product regulation, and dissemination of best practices would enhance the feasibility and reach of natural tick control solutions.

4. Community-Based Implementation

Formation of farmer groups or cooperatives to collectively process garlic and prepare oil can lower individual costs and improve access. Pilot programs at the community level can demonstrate practical benefits and build confidence in the use of garlic oil.

5. Monitoring and Evaluation Systems

A continuous monitoring system should be established to evaluate the effectiveness of garlic oil under varying environmental and herd management conditions across seasons.

In conclusion, garlic oil offers a promising alternative for tick control in cattle under smallholder farming conditions. With proper research, training, and institutional support, it can contribute meaningfully to sustainable livestock health management in Zvimba District and similar rural communities.

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Research Questionnaire. **No:**

My name is Tariro Mango a final year student at Bindura University of Science Education studying BSc in Animal Science and Technology (Hons). As part of my studies, I am carrying out a survey research project with the title, evaluation of the efficacy of garlic oil as a natural tick control method in cattle for smallholder farmers in Zvimba District. The questions on the questionnaire will be used in this study only and all the responses remain confidential. I Tariro Mango will be held accountable for any information that will be leaked. The aim of the study is to improve cattle production for communal smallholder farmers.

Section A: Demographic Information

1. Gender: ☐ Male ☐ Female
2. Age: ☐ Below 25 ☐ 25–35 ☐ 36–50 ☐ Above 50
3. Level of education:

No formal education ☐ Primary ☐ Secondary ☐ Tertiary ☐

4. Years of Experience:

Less than 5 years ☐ 5–10 years ☐ More than 10 years ☐

5. Number of cattle owned:

1–10 ☐ 11–20 ☐ 21-30 ☐ 31-40 ☐ 41-50 ☐ More than 51 ☐

Section B: Awareness and Adoption of Garlic Oil

6. Are you aware of garlic oil as a tick control method for cattle?

Yes ☐ No ☐

7. Have you used garlic oil as a tick control method?

Yes ☐ No ☐

8. If yes, how did you learn about it? (Tick all that apply)

☐ Fellow farmers
☐ Agricultural extension officers
☐ Radio/TV
☐ Social media

Other (please specify): _____

9. How effective is garlic oil in controlling ticks, in your experience (if used)?

- ☐ Very effective
- ☐ Moderately effective
- ☐ Not effective
- ☐ Not sure

Section C: Affordability and Cost Comparison

10. How much does garlic oil cost per unit (e.g., per 100ml)? (If you buy it)_____ZWL/USD

11. If you use chemical acaricides, how much do you spend per month on them? _____ZWL/USD

12. If you have used both methods, which one is cheaper for you? Please estimate the cost difference.

Example: Garlic oil is cheaper than chemical acaricides by approximately _____ ZWL/USD per month._____

13. What are the additional costs associated with using garlic oil (e.g., application equipment, labor), and how much do they amount to per month?_____ ZWL/USD

14. Would you continue using garlic oil if it became more accessible and affordable?

Yes ☐ No ☐ Maybe ☐

Section D: Additional Comments

16. List any benefits you observed when using garlic oil:_____

17. What are the major challenges that prevent you from using garlic oil?

- ☐ Lack of knowledge
- ☐ Difficult to prepare or apply
- ☐ Not available
- ☐ Expensive
- ☐ Not effective

Other (please specify): _____

18. What support would help you adopt garlic oil as a tick control method?_____

19. Any other comments or suggestions regarding natural tick control methods:_____

APPENDICES

Appendix 1: Multiple linear regression

Coefficients	B (Unstandardized coefficients)	t-value	p-value
Intercept	0.823	2.563	0.012
Age	-0.012	-0.755	0.421
Years of experience	0.035	1.758	0.081
Awareness of Garlic oil	0.421	4.527	0.001
Number of cattle owned	0.007	0.656	0.512
Cost of Garlic Oil	-0.051	-2.317	0.023
Affordability	0.234	2.294	0.026

Appendix 2: multiple linear regression output

Output = 0.823 -0.012 age + 0.035 years if experience + 0.421 awareness of garlic oil + 0.007 number of cattle owned -0.051 cost of garlic oil + 0.234 affordability