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Prevalence, knowledge and practices of Merino sheep farmers in-relation to tick control in the Mountain Kingdom of Lesotho

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Abstract

Merino sheep in the Mountain Kingdom of Lesotho are infested by ticks. Sheep production system in Lesotho is mainly by an extensive and communal management system. This type of management system can predispose sheep to cross-infestation of ticks. Therefore, this study was designed with the following objectives; to determine farmers' educational level in relation to their awareness of ticks' infestation in their flocks, to determine the prevalence of tick genera in each of the four agro-ecological zones (AEZs) and to determine the efficacy of ivermectin (1%) in controlling each tick genus. Four hundred and three (403) respondents (sheep farmers) were interviewed. Seven hundred and twenty sheep were examined for the prevalence of ticks. These ticks were identified in the laboratory using taxonomic keys with the aid of a stereoscope. The longitudinal GEE logistic regression was used to analyse the data for ticks' prevalence to ascertain the effect of AEZ, age and ivermectin (1%) efficacy on ticks' infestation. Data on ticks' concentration was analysed by Poisson model. The results indicated that there was a significant ($p<0.05$) difference in demographic characteristics of sheep farmers; most of the respondents achieved only primary level education and that in terms of age groups, there was no statistical difference ($P > 0.05$) between AEZs whereas more sheep farmers were married ($P < 0.05$) in all the four AEZs. There were more sheep farmers ($P < 0.05$) with small flock sizes of 1-10 than medium (20-50) and large (50+). The results further indicated that the *Rhipicephalus'* population in all four AEZs was 36% while the other species were relatively non-existent (> 1%); farmers' education level is very low (primary school certificate) and their awareness of the menace of ticks in their flocks is also very low*; Rhipicephalus* tick genus is the most prevalent and the overall efficacy of ivermectin (1%) against *Rhipicephalus* tick genus at 30, 60 and 90 days after injection were 23.6%, 0% and 0%, respectively.

Keywords: Agro-ecological zones, Ivermectin (1%), Lesotho, Merino sheep, Ticks

Introduction

Lesotho is a developing country totally surrounded by South Africa (The Observer, 2010). Agriculture is a major source of income for more than 80% of the rural population in Lesotho with a total land area of

30,355 square kilometres with only 9% of arable land (Bureau of Statistics, 2011). For ease of reference, the entire Mountain Kingdom of Lesotho is divided into four agro-ecological zones (AEZs): (i) the Lowlands, (ii) the Sengue River Valley, (3) the Foothills and (4) the Highlands. In Lesotho, sheep accounted for 49% of the total national livestock population (Bureau of Statistics, 2019). The population size of sheep varies among agro-ecological zones (AEZs), with the highest population (787,316) found in the highlands region (Bureau of Statistics, 2019). The highlands seemingly provide favourable AEZ conditions for extensive sheep production due to its large size which is dominated by rangelands and sparsely populated human settlements compared to the other AEZs where the arable land is used for crop production rather than for livestock production (Chatelet, 2008; Rampai, 2017).

Losses attributed to tick-borne diseases include mortality, production losses (wool quality and quantity), diagnostic costs, veterinary treatment and control costs of ticks (Eskezia & Desta, 2016). In sub-Saharan Africa, tick-borne pathogens are endemic and transmitted by ixodid tick species causing both clinical and subclinical infections (Mahlobo & Zishiri, 2021).

Merino sheep is much prized for its wool which is regarded as being the finest and softest of any wool (Megdiche *et al.,* 2019). For over a decade, the export of wool has accounted for 58.3 percent of agricultural exports in Lesotho. In the mountains where poverty is highest, revenue from sheep is often the only source of income for families from their agricultural endeavours (Rantšo, 2016). Control measures of ticks rely greatly on the correct identification, and understanding of their ecology, distribution and seasonal activity (Domingos *et al.,* 2013). It has been established that the distribution of ticks in different geographical environments can be attributed to a variety of factors like geo-climatic conditions, general farm management system and sheep farmers' awareness/level of education (Mafisa, 1993; Chatelet, 2008; Eskezia; 2016; Rampai, 2017). Therefore, the objectives of the current study were to determine farmers' awareness of the presence of ticks in their flocks and the level of education of the sheep farmers in relation to the prevalence of ticks in their flocks; to determine the prevalence of tick genera in each of the four agro-ecological zones (AEZs) and to determine the efficacy of ivermectin (1%) in controlling each tick genus.

Materials and Methods

Study area

The study was conducted in summer in the four agro-ecological zones (AEZ) of Lesotho. The country is situated within the Southern African plateau at an elevation of between 1,500 m and 3,482 m above sea level with a total land mass area of 30,355 square kilometres. It is divided into four AEZs (Figure 1) based on climate and elevation with the total area coverage of: Lowlands (17%), Senqu River Valley (9%), Foot-hills (15%) and Highlands (59%) (Olaleye *et al.,* 2012). The Lowlands are in the west lying between altitudes of 1500m and 1830m above sea level and are characterized by relatively high rainfall and moderate to high temperatures. The Foothills are in the centre between 1830 and 2130 meters above sea level with lower rainfall and temperatures compared to the Lowlands. The Senqu/Orange River Valley runs from east to west across the country is characterized by low rainfall especially in the south-western part and it lies between 1500 and 2250 meters above sea level. The Highlands are characterized by very cold winters. They rise to elevation of 3500 meters and constitute by far the largest, and yet the least

Figure 1: Lesotho map showing the four AEZs (Olaleye *et al*., 2012)

densely populated part of the country. Livestock production is more commonly found in the Highlands (Mafisa, 1993).

Study design and data collection

A cross sectional baseline study was carried out in four AEZs using questionnaire where 403 sheep farmers responded. In total exactly 720 sheep were sampled from the four AEZs: Lowlands, Senqu River Valley, Foot-hills and Highlands. One wool shed only was selected at random to represent each AEZ which was further subdivided into four areas. In each area three farmers were also selected at random. Each farmer supplied 15 animals comprised of 5 lambs (less than 1 year), 5 juveniles (1-2 years) and 5 adults (2-3 years) to be used as experimental animals. Dentition was used to estimate the age of animals. The animals were kept under semi-intensive production system as the normal practice of animal management. Tick samples were first collected and counted in January as day 0 before the subcutaneous (SC) injection of ivermectin (1%) (Ivermectin is a mixture of two avermectins, comprising roughly 90% 5-O-demethyl-22,23-dihydroavermectin A_1a (22,23-dihydroavermectin B_1a) and 10% 5-O-demethyl-5-de(1-methylpropyl)-22,23-dihydro-25-(1-methylethyl)avermectin A_1a (22,23-dihydroavermectin B_1a). Thereafter, ticks were collected at 30-, 60-, and 90-days post administration of the drug. Ticks were searched by carefully examining the roots of the wool/skin using naked eye and palpation at predilection sites (i.e. inside earlobes, ventral surface, flanks, back and interdigital spaces). Different stages of ticks (larva, nymph and adult) were collected manually using forceps to avoid damage to their mouth parts. The collected ticks were transferred into sample containers containing 70% ethanol, kept in a labelled screw-lid container and then preserved in ethanol before identification in the laboratory using taxonomic keys with the aid of stereoscope in the Department of Biology laboratory. All the required information such as date, location, predilection sites and age were recorded.

The preserved ticks were identified by their morphological features through the stereomicroscope using a standard keys provided by Walker *et al*. (2003). The observed features were tick length using well calibrated ruler of the stereomicroscope, paying attention to engorged ticks with blood, presence or absence of eyes, long or short mouth parts, small or big scutum, colour of scutum (ornate or inornate) and shape. For the reporting of tick species encountered, we only focus on the adult stages of these ticks as a large number of immature ticks can be easily overlooked during field collection because of their small size resulting in a biased estimate of counts.

Data analysis

The data obtained from the survey was entered into Microsoft Excel 2010 and transferred to Statistical Package for Social Sciences (SPSS version 20) for statistical analysis. Individual data were coded into appropriate variables and assigned numerical values. The descriptive statistics was employed in order to determine the means and standard errors of the mean ($\underline{X}$±S.E.M.). Chi-Square test was subsequently used to determine the level of association between dependable variables (agro-ecological zones) and the predictor variables (sex, level of education and flock size). The mean (±S.E.M.) results were presented in terms of percentages.

The experimental data was analysed with General Linear Model (GLM) to determine the effect of agro-ecological zone, age and ivermectin efficacy on the prevalence and abundance of ticks' infestation in sheep. The Generalized Estimating Equation (GEE) was used to analyse the tick abundance in each agro-ecological zone and age group. GEE was also used to compare risk effect of independent variable upon dependent variable with ticks' genera count adopting a binary logistic for identifying ticks' prevalence. The confidence level was set to be 95% for determining any significant differences on the factors evaluated between the different categories such as level of infestation within the animal age groups, between agro-ecological zones and before and after ivermectin treatments.

Results

The results are indicated in Table 1. They showed that the difference between males and females sheep farmers in relation to flock size and the prevalence of ticks in the four AEZs combined was not significant ($P>0.05$). The difference between young, middle aged and adult aged groups engaged in sheep farming in four AEZs combined was significantly different ($P< 0.05$). The difference in level of education of farmers compared to the prevalence of ticks across the four AEZs was non-significant ($P>0.05$). The difference in the percentage of sheep farmers owning small flock size in all AEZs was non-significant ($P>0.05$).

In all AEZs the identified ticks' genera were: *Rhipicephalus (*36%), *Boophilus* (0.7%), *Amblyomma* (0.4%), *Hyalomma* (0.2%) and *Otobius* (0.5%).

Table 1: Farmers' demographic profile in the four agro-ecological zones of Lesotho

Category	Senqu%	Lowlands%	Foothills%	Highland%	χ^2 value	Sig
Gender						
Male	64	67	66	58	2.11	0.542
Female	36	33	34	42		
Age						
Youth age	47	65	54	56	1.20	0.000
Middle age	46	58	56	57		
Older age	41	44	40	43		
Marital status						
Single	15	22	21	14	5.02	0.006
Married	70	60	62	78		
Level of education						
Primary	48	56	50	50	45.83	0.000
Secondary	17	25	21	15		
High School	10	7	14	3		
Tertiary	6	5	3	0		
None	7	7	13	33		
Flock size						
Small	74	81	85	81	11.63	0.065
Medium	22	18	8	22		
Large	5	1	6	6		

χ^2 = Chi square, Sig = significance value

Rhipicephalus was therefore the most prevalent (Table 2). The level of farmers' awareness of the tick problem in their flocks in the four agro-ecological zones was very low as compared with their awareness of other ecto-parasites in their flocks (Figure 2).

Amblyomma and *Hyalomma* genera were having very low prevalence so much that they were unable to be analysed by GEE. Only *Rhipicephalus, Boophilus* and *Otobius* were statistically analysed as illustrated in Table 3.

Rhipicephalus prevalence was higher in the Foothills (48%) compared to Lowlands (41%), Senqu River Valley (34%), and Highlands (6%). The chances of increase in *Rhipicephalus* prevalence from the Highlands to Senqu River Valley was 0.03 times and then to Lowlands was 0.01 and the increase was found to be significant (p<0.05). The

Table 2: The combined overall percentage of ticks identified in the four AEZs

Tick	NO. of sheep Examined	Prevalence Percentage (%)	Significance (p<0.05)
Rhipicephalus spp.	720	36.0	0.02
Boophilus spp.	720	0.7	0.00
Hyalomma spp.	720	0.2	0.00
Amblyomma spp.	720	0.4	0.00
Otobius spp.	720	0.5	0.00

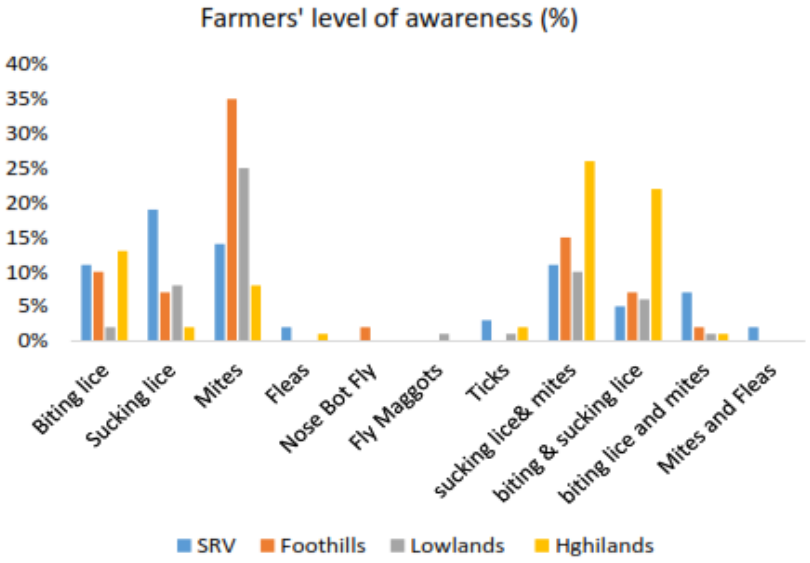

Figure 2: Sheep farmers' level of awareness of the presence of ticks compared to other ecto-parasites in the four agro-ecological zones of Lesotho

Table 3: Prevalence of ticks' genera by agro-ecological zones of Lesotho

AEZ	No. examined	Prevalence (%)	SD	Exp (B) %
Rhipicephalus				
Senqu	156	34[a]	2.997	0.01
Lowlands	190	41[b]	4.962	0.01
Foothills	208	48[c]	3.317	0.01
Mountains	161	6[d]	0.507	1
Boophilus				
Senqu	156	1[a]	0.125	0.00
Lowland	190	1[a]	0.138	0.00
Foothills	208	1[a]	0.000	0.00
Mountains	161	0[b]	0.000	1
Otobius				
Senqu	156	1[a]	0.000	0.00
Lowlands	190	1[a]	0.000	0.00
Foothills	208	0[b]	0.000	0.00
Mountains	161	0[b]	0.000	1

Values within the same rows with different letters (a, b, c, d) are significantly different ($p<0.05$). Exp. (B)= Exponential Beta. SD = Standard deviation. NO = Number

Table 4: The efficacy of ivermectin (1 %) in the four agro-ecological zones

Tick Genera	Total No. of sheep examined	Total No. & % of sheep infested by ticks before injection	Total No. of sheep infested by ticks after 30 days of injection	Total No. of sheep infested by ticks after 60 days of injection	Total No. of sheep infested by ticks after 90 days of injection
Rhipicephalus	720	261 (36.25%)	198 (23.6%)	261 (0 %)	259 (0 %)
Boophilus	720	6	4	5	5
Ambyomma	720	5	0	0	3
Hyalomma	720	11	2	0	4

results give a clear picture that the chances are higher ($p<0.05$) for the sheep reared in the Foothills to get tick infestation compared to those kept in the Mountains.

Table 4 indicates the overall efficacy of ivermectin 1% injection on the most prevalent tick genus *(Rhipicepalus*) after 30 days (23.6%), 60 days (0 %) and 90 days (0 %). The results showed that 261, 6, 5, 11 and 4 sheep were infested with *Rhipicephalus, Boophilus, Amblyomma, Hyalomma* and *Otobius* tick genera respectively before ivermectin (1%) injection. The most prevalent tick genus was *Rhipicephalus* which did not show a significant response to ivermectin (1%) before injection (261), after 30 days of injection (198), 60 days of injection (261) and after 90 days of injection (259) of sheep still being infected. flocks is very low. This could be as a result of low level of education since more than 50% of sheep farmers have only a primary school leaving certificate.

Discussion

The demographic results of sheep farmers showed that only farm size, age, marital status and level of education had a significant effect on the prevalence of ticks across all AEZs. Bigger farm sizes could be very difficult to manage by the elderly and/or the younger boys/girls. Married women may also be affected when they are pregnant or nursing their newborn babies. Regular formal/informal education should be conducted in Lesotho in order to create farmers' awareness of the presence of ticks, economic effects of ticks and control measures against the most prevalent ticks in their agro-ecological zones. This is necessary because the current study indicated that farmers' awareness of the presence of ticks in their

Ticks breed very quickly, feed on sheep blood and during feeding they may transmit tick-borne diseases (Rabhari *et al.*, 2007). Ticks breed very quickly, feed on sheep blood and during feeding they may transmit tick-borne diseases. This double negative effect of blood-letting and disease transmission has a profound impact on the survival and productivity indices of the sheep industry. The results of the current study indicated the relative presence of the five genera of ticks in sheep reared in all AEZs of Lesotho. Similar findings were reported in Lesotho by Zongezile *et al.* (2023) in four geographical zones where they found the presence of *Rhipicephalus,*

Boophilus, Amblyomma, Hyalomma and *Otobius* ticks in sheep. However, in Iran, Yakhchali *et al.* (2012) discovered that the most prevalent genus of tick was *Hyalomma* which is in contrast with the current study where we discovered that the most prevalent genus of tick was *Rhipicephalus*. This difference could be due to differences in micro-climates of the two studies and might be due to the reason that our current study concentrated on sheep while Yakhchali *et al.* (2012) studied in both sheep, goats and cattle. Our findings are in agreement with a previous study conducted in Lesotho (Diseko, 2018) where the prevalence of *Rhipicephalus, Hyalomma* and *Otobius* were also identified. However, the difference between the two studies is that additional genera (*Amblyomma* and *Boophilus*) were identified in the current study and that might be due to the efficiency and detailed identification procedure in the current study. The other possible factor could be due to the difference in seasons when both studies were conducted. In the current study, it was conducted during the summer period whereas Diseko (2018) conducted his research work from autumn to winter. The other difference between the two studies is that the former was just interested in the presence of ticks and not the relative percentages of occurrences of each tick.

The obtained tick prevalence percentages from the current study is lower compared to that obtained in the study done in Eastern Ethiopia by Mohammed *et al*. (2015) where 79.7% tick infestation was found. The mere presence of ticks in the four AEZs indicates that control measures/eradication measures should be instituted at sheep farmers' level in order to limit or totally eliminate the effect of ticks' infestation on sheep productivity indices. Bigger farm sizes could be very difficult to manage by the elderly and/or the younger boys/girls. Married women may also be affected when they are pregnant or nursing their newborn babies.

Ixodid ticks reproduce quickly preferably in areas with high temperatures. Flocks reared at AEZs with warmer temperatures such as the Lowlands (Leribe and Mafeteng) were found to have high tick infestation compared to those reared at cooler temperatures such as the Highlands (Pegram *et al.,* 1981; Kumsa *et al.,* 2012). Ticks' prevalence was found to be higher in the Lowlands, Foothills and Senqu River Valley. Our findings agreed with previous studies conducted in some countries whereby a higher prevalence of ixodid ticks infestations was in the midland and lowland zones than in the highland agro-ecological zone ticks (Pegram *et al.,*1981; Kumsa *et al*., 2012.

This current study was carried out in the middle of hot summer season (January), when relative humidity (RH) was high as well as the vegetation coverage was massive hence adult ticks attached onto the sheep body are expected to be at their peak of reproduction. Our finding revealed high *Rhipicephalus* prevalence at warmer dry AEZ (Lowlands-Mafeteng district) than in cooler wet AEZs (Highlands – Mokhotlong district). These findings tally with the work of Walker *et al.* (2003) who indicated that hard tick, principally three host of the genera *Rhipicephalus* survived better in dry/warmer AEZs (Foothills and Lowlands). These AEZs favour the survival and faster reproduction activity in ixodid ticks (Pegram *et al.,* 1981; Teshome, 2002; Serste & Wossene, 2007; Mulugeta, 2008; Kumsa *et al*., 2012). The distribution of ticks within a specific habitat depends on several environmental and climatic factors such as annual rainfall, atmospheric temperature and RH, vegetation cover, management practices, altitude and host availability (Kumsa *et al.,* 2012). In our study, the prevalence of some ticks' genera were very low such as *Boophilus, Hyalomma, Amblyomma*
and *Otobius* in all the four AEZs. It has been reported that these ticks' genera are usually associated with lowland rainforest and secondary grassland, with a clear increase in the vegetation cover (Mekonnen *et al.,* 2001; Lorusso *et al.,* 2013). In Lesotho such massive vegetation cover is lacking due to the high altitudes of above 1,800 metres above sea level within the entire country.

In terms of the efficacy of ivermectin (1%) in the control of ticks, the most prevalent tick genus *(Rhipicephalus*) was not significantly sensitive to the treatment even for just 30 days' duration (27%). This might be due to resistance to the indiscriminate use of ivermectin (1%) by local sheep farmers in all the districts of the Mountain Kingdom of Lesotho. Another possible reason is that a 1% ivermectin may not be potent enough to control ticks. A higher concentration might be useful in controlling ticks in sheep for example a 3.5% ivermectin solution which is currently in the market might be potent enough. The non-effectiveness of ivermectin was also observed with the other relatively less prevalent genera of ticks in the current study. This further reinforced the ineffective potency of ivermectin against the most prevalent genus (*Rhipicephalus*). In conclusion, the current study has established that (i) *Rhipicephalus*' population in all four AEZs was 36% while the other species were relatively non-existent (less than 1%) in all four AEZ (ii) farmers' education level was very low (mostly primary school certificate

holders) in relation to their awareness of the menace of ticks in their flocks (iii) *Rhipicephalus* tick genus is the most prevalent in the Mountain Kingdom of Lesotho (iv) The overall efficacy of ivermectin (1%) against *Rhipicephalus* tick genus at 30, 60 and 90 days after injection were 23.6%, 0% and 0%, respectively.

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Conflict of Interest

The authors declare that there is no conflict of interest.

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