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Seasonal Dynamics and Distribution of Ticks in Rwanda: Implications for Tick Control Strategy in Rwanda

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Abstract: The broad objective of this study was to examine the dynamics and seasonal distribution of tick species in Rwanda in three agro-ecological zones namely high altitude (Gishwati), the mid altitude (Huye) and the lower altitude zones (Nyagatare). Ten cows per zone were identified and used for collecting ticks monthly on a period covering the short dry season and long rainy season from December 2002 to June 2003. These animals were not treated and remained on pasture land. The results revealed that much of the variance in tick population is explained by the altitude and rainfall ($p<0.05$). Ticks were endemic in the mid altitude zone with counts ranging from 239 ticks to 1552 ticks per month and this region accounted for 69% of all collected ticks. Ticks collected in other areas vary from 146 to 271 for the lower altitude zone, and 35 to 275 for the high zone and this represents 18.7% and 12.3% per 100 of all collected ticks. The dominant species is *Rhipicephalus appendicaltus* (96%). Effective tick control programs need to take into account the altitude and rainfall variations in Rwanda.

Key words: Altitude, density, humidity, rainfall, Rwanda, temperature and ticks

INTRODUCTION

In Rwanda, agriculture underpins the livelihoods of at least 90% of the population. Between the years 1990 and 2002, exportable products from agriculture have accounted for 50% of the national Gross Domestic Product (GDP) (MINECOFIN, 2002). The livestock sub-sector has increasingly become eminent in terms of its contribution to household nutrition and food security and nationally through exports over the last few years. However, sustainability of this sector has been negatively affected by the high incidence of animal diseases and pests. Losses attributable to livestock diseases account for 25% of the value of cattle production. Common diseases in Rwanda include East Coast fever, anaplasmosis, babesiosis, trypanosomiasis, anthrax, brucellosis, tuberculosis, foot-and-mouth disease (FMD) and contagious bovine pleuropneumonia (CBPP). A significant proportion of livestock diseases are carried principally through ticks.

Ticks are a problem in livestock production and cause significant economic losses, mainly in dairy cows (Tittapalapong, *et al.*, 2004). The teats are damaged resulting in a reduction in milk yield, which is a cheaper source of protein to rural resource-poor farmers. Ticks also damage the skin, thereby reducing hide quality and creating room for the secondary sources of infection (ibid). Most of the rangelands in East Africa are inhabited by agro-pastoralists who depend on subsistence production (Teer, 1985). They are always at the mercy of insects, diseases, predators, drought, floods, and other natural disasters. Their livelihoods are mostly dependent on livestock. Among the major constraints to livestock productivity in agro-pastoral areas are ticks and tick-borne diseases (TBDs), and tsetse flies and trypanosomes (Ocaido, *et al.*, 1996). Of the diseases caused by ticks and TBDs, East Coast fever (ECF, Theileriosis), anaplasmosis, babesiosis, and cowdriosis are among the most important and widespread (Otim, 2000).

In Rwanda, the damages attributable to ticks are a major constraint to increased livestock production. In bovine production, the first economic damage caused by these sucking blood parasites is the transmission of many diseases such as Theileriosis, Anaplasmosis and Babesiosis. Ticks are also sources of anemia, traumatism and toxemia. The main preventive measures against these vectors in the country are based on the use of acaricides. Effective control of ticks must take into account the species present in the region, their density and their dynamics. This study seeks to determine the distribution of different species of ticks over two seasons in wet and dry season in Rwanda and relate them to temperature and rainfall patterns.

MATERIALS AND METHODS

This study was conducted in Rwanda in three zones namely high (Gishwati), medium (Huye) and low (Nyagatare) altitude zones. Collection of ticks was made during seven months from December 2002 to June 2003.

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The region of high altitude (Gishwati): This region is comprises the "Crete Congo Nil" which separates Nile and Congo basins. Altitude ranges from 1900m to over 3000m. Rainfall varies throughout the month from 78.5 to 150 mm per month with an annual average that exceeds 1400mm per annum. The relative humidity is between 79.3 and 87.5% and an average of 84.5%. Temperatures range between 5.9 and 25.4 ºC, with an average of 15.8 ºC (Fig. 1, 2 and 3). The region is characterized by the presence of pastures with Kikuyu Grass.

The region with medium altitude (Huye): This is an area of plateau, the altitude varies between 1600 and 1700 m, rainfall varies between 19mm to 246.3 mm per month. The annual averages are between 1100 and 1250mm. Relative humidity varies between 59 to 77% with an annual average of 72.1%. The average daily temperature is between 19.2 and 20.6 ºC and average annual temperature is 20.1 ºC (Fig. 1, 2 and 3). Livestock is semi extensive.

The region with low altitude (Nyagatare): This region includes the savannas of eastern countries. It is a zone with an average altitude ranging from 1250 to 1500 m. The rainfall is less varied during the study period of 13 to 137mm per month with an annual average of 900mm. Relative humidity varies between 60.8 and 81.5%. The average daily temperature is evaluated ranges from 21.7 and 32.2 ºC and average annual temperature is 22 ºC (Fig. 1, 2 and 3). It is a pastoral region with over 40% of the national herd raised in a semi-extensive system.

Experimental Animals and tick collection: At each site, collection of ticks was made during seven months from December to June on ten adult females in good condition without any treatment. Ticks were collected mainly from the head, ear, hips and tails of the animals. On field ticks were kept separately in identified tubes containing 70% alcohol to prevent drying. In the laboratory, ticks were kept in the same tube with alcohol in a refrigerator at 4 ºC until counting and identification.

Counting and Identification: For the identification of ticks, the researchers used identification keys as described by Madder (2000). Ticks were placed on plasticine and fixed on the stereoscopic microscope. The ticks were placed in the ventral position, then in the back position. The identification was carried to a species level. Analysis of variance (ANOVA) based study was also done using SPSS version 10.

RESULTS

Seasonal dynamics of different species of ticks: Ticks have shown a permanent presence throughout the study period, there was a constant presence of three species of veterinary importance: *Rhipicephalus appendiculatus* (Rh App) *Amblyomma variegatum* (A. Var) and *Boophilus decoloratus* (B. dec). These three species account for 99.7% of total ticks collected in the country. Two species of ticks, *Rhipicephalus compositus* (Rh. comp.) and *Ixodes ricinus* (ix. ric) were common in December.

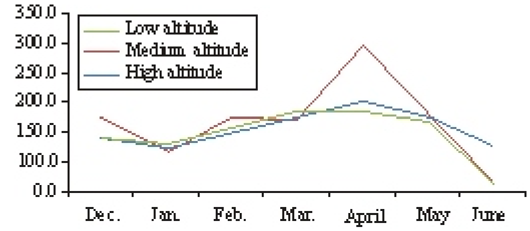

Fig. 1: Average changes of precipitation during the study period

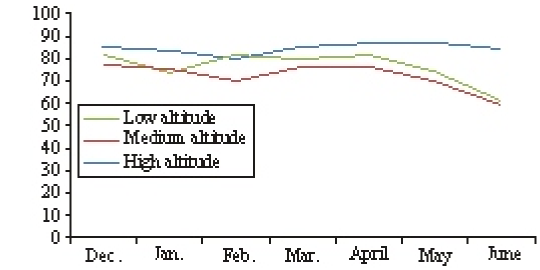

Fig. 2: Average change of relative humidity during the study period

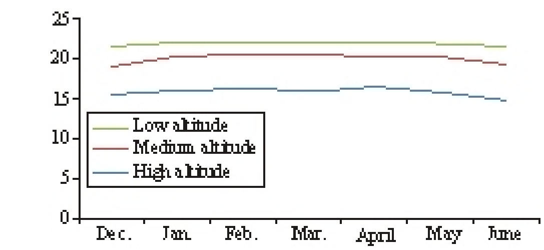

Fig. 3. Average temperatures change during the study period

Variation of tick species among different ecological zones: The population of ticks in the three study areas was dominated by one species "*Rhipicephalus Appendicaltus*", representing more than 96.9% of collected ticks.

In areas of high altitude, characterized by heavy rainfall and average temperatures ranging between 12 and 18ºC, *Rhipicephalus appendiculatus species* was prevalent and constituted 97.5% of the total collected ticks. On the other hand, the incidence of Rhipicephalus *compositus and* Boophilus *decoloratus* was low with 2.2 and 0.3% prevalence rate respectively. These two were common in December (Table 1). The sunny months of December, January and February corresponding to early dry season are characterized by high tick counts in the area. The density is 183, 275 and 174 respectively, representing 21.2, 31.8 and 20.1% respectively of all collected ticks during the study period in the zone. During the rainy months of April, May and June, there was a decrease in the tick population, 6.7, 4.2 and 5.9%.

In the mid altitude zone (Table 2), *Rhipicephalus appendiculatus* was most prevalent at 96.2%, other species of ticks present are *Boophilus decoloratus* (2.2%) *Amblyomma Variegatum* (1.6%). The three species occur more or less during the two seasons but with large differences between the seasons as much as the first. Whilst *Rhipicephalus compositus* species was found in the high altitude zone, it was not present in the middle altitude area. The months of January and May are characterized by high population densities of ticks, 801 and 1552 respectively. This is explained by the presence of a conducive temperature and relative humidity suitable for the development of the species *Rhipicephalus appendiculatus*. The months of March and April have the lowest density of ticks (304 and 234 respectively).

In the lower altitude zone, characterized by low and erratic rainfall, the number of ticks varies significantly across months (Table 3), nor no obvious changes in tick populations related to the presence or absence of rain variation. The most important species is *Rhipicephalus appendiculatus* representing 98.8%. Other rare species are *Amblyomma Variegatum* (1.1%) and *Ixodes Ricinus* (0.1%). The species *Amblyomma variegatum* is present only in areas of medium and low altitude. The variation of the density of ticks through the months and between seasons is not as remarkable as in the previous two zones.

Overall change in tick populations in the Country: The period from December to February is characterized by a large number of ticks with 1148, 1228 and 1016 ticks respectively (Fig. 4). On the other hand, March (553) and April (537) are characterized by decreasing number of ticks when compared to the previous period. The incidence of ticks surges upwards in month of May (1734), and then decreases in June (830). There was a statistically significant difference in tick populations across the three sites, with averages of 123.4, 694.6 and 188 ticks recorded for high, medium and low altitudes respectively.

Generally the study findings agree with extant literature which indicates that tick densities decrease at higher altitudes (Cadenas and Burri, 2008; Gilbert, 2009). The relationship between tick populations and rainfall in the three study zones was analyzed. In the high altitude zone, there was a negative relationship between rainfall and tick counts (-0.612). Similarly, there was a negative correlation between tick population and rainfall in the middle altitude region (-0.285). On the other hand, there was a positive relationship between the two parameters in the low altitude areas (0.284). The microclimate characteristic to low altitude areas of Rwanda are comparable with those of East and Central Africa hence these results have been confirmed by studies done in East and Central Africa (Newson, 1978). These temperature-tick population relationships have been also been illustrated in Rwanda by Bazarusanga, *et al.* (2007).

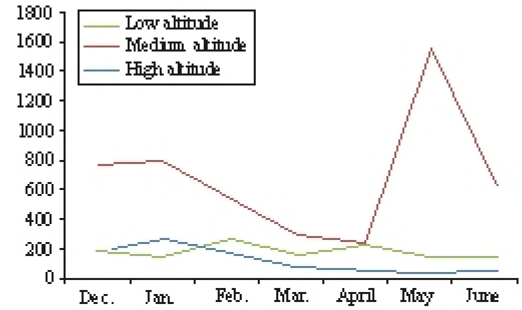

Fig 4. Variation of the overall number of ticks during the study period

Table 1: Dynamics of different species of ticks in the high altitude zone: Gishwati

Month	Rh. app.	Rh. com.	A. var.	B. dec.	Ix. ric.	Total	%
December	161	19	0	3	0	183	21.2
January	275	0	0	0	0	275	31.8
February	174	0	0	0	0	174	20.1
March	87	0	0	0	0	87	10.1
April	58	0	0	0	0	58	6.7
May	36	0	0	0	0	36	4.2
June	51	0	0	0	0	51	5.9
Total	842	19	0	3	0	864	
Percentage	97.5	2.2	0.0	0.3	0.0		

(Species of ticks collected)

Table 2: Dynamics of different species of ticks in the mid zone: Huye

Month	Rh. app.	Rh. com.	A. var.	B. dec.	Ix. ric.	Total	%
December	746	0	21	8	0	775	15.9
January	756	0	30	15	0	801	16.5
February	551	0	2	18	0	571	11.7
March	304	0	0	2	0	306	6.3
April	234	0	2	3	0	239	4.9
May1	508	0	14	30	0	155	231.9
June	580	0	8	30	0	618	12.7
Total	4679	0	77	106	0	4862	
Percentage	96.2	0.0	1.6	2.2	0.0		

(Tick species)

Table 3: Dynamics of different species of ticks in the lower altitude zone: Nyagatare

Months	Rh. app.	Rh. com.	A. var.	B. dec.	Ix. ric.	Total	%
December	187	0	2	0	1	190	14.4
January	150	0	2	0	0	152	11.5
February	269	0	2	0	0	271	20.5
March	157	0	3	0	0	160	12.1
April	240	0	0	0	0	240	18.2
May	144	0	2	0	0	146	11.1
June	157	0	4	0	0	161	12.2
Total	1304	0	15	0	1	1320	
Percentage	98.8	0.0	1.1	0.0	0.1		

(Tick species)

Table 4: Tick variations by altitude (One-way ANOVA)

Source	Sum of Squares	DF	MSE	F	Sig (P=0.05)
between groups	1368462	2	684231.05	10.31	0.01
within groups	1194391	18	66355.07		
Total	2562853	20			

The most common species in Rwanda is *Rhipicephalus appendiculatus* representing 96.9% of collected ticks. This species is found in all three areas. *Boophilus decoloratus* species was present in the mid and low altitude zones (1.5%). Similarly, *Amblyomma variegatum* occurs in areas of medium and low altitude (1.3%). On the other hand, *Rhipicephalus compositus* is present only in the high altitude zone with 0.3%, while *Ixodes Ricinus* was found to be rare (0.09%). The effect of altitude and rainfall on tick populations was also examined using two-way analysis of variance (Table 4).

While ticks are naturally endemic in Rwanda as reflected by the intercept ($p<0.05$), their variations are largely influenced by altitude (Table 5). This could attributed to the influence of altitude on ambient temperature which is critical for tick development and survival. According to the results, the interaction between the altitude and rainfall does not significantly impact on tick populations ($p>0.05$). Discussions

In general, ticks are ubiquitous in Rwanda under different ecological conditions. The results of the two-way analysis of variance reflected that tick populations are influenced mainly by altitude with less prevalence at high altitudes. These results are consistent with studies in Africa and Europe (Gilbert, 2009). The middle altitude zone accounted for more than 2/3 of all collected ticks in the study period. This could be attributed to the influence of high precipitation, humidity and relatively high temperatures experienced in the area and host abundance. In the low altitude zone, there was a moderate density with 18.7% as a result of higher temperatures and lower relative humidity. This has been found to have a negative correlation with the population of ticks (FAO, 1982). Five different species of ticks were identified during the study period. However, three species were relatively dominant and these were *Rhipicephalus appendiculatus*, *Boophilus decoloratus*, and *Amblyomma variegatum*. These results are similar with those Walker *et al.* (2000), who showed that *Rhipicephalus appendiculatus* is the most endemic species of ticks in Rwanda and causes the most damage in animal husbandry. According to Morel (1981), *Rhipicephalus appendiculatus* lives almost everywhere between the altitudes of 1000 to 2500m, but the optimal conditions are found between 1200-2500m. This would explain the big increase recorded in the month of May in the mid altitude zone. Rhipicephalus compositus is found only in the high altitude zone, these results are confirmed by Nzige (1978) and Morel (1981). The month of December seems rich in species during the study period. From January, only three species *Rhipicephalus appendiculatus*, *Boophilus decoloratus* and *Amblyomma variegatum* were existent in the study sites (FAO, 1982). Their relative abundance is affected by seasonal dynamics. According to the study, the species *Rhipicephalus appendiculatus* is adaptable to different ecological conditions since it was found in the low, medium and high altitude zones. *Boophilus decoloratus* was limited in medium and low altitude zones. According to Nzige (1978) this specie is common in areas not exceeding 1950 meters. *Amblyomma variegatum*, the third species in terms of importance shows a constant distribution in the areas of low and medium altitudes but It was absent in the high altitude zone. Nzige (1978) observed that this species is found in altitudes of between 1500 and 1700 meters.

Table 5: Effect of altitude and rainfall on tick population

Source	Degrees of Freedom	F	Sig (P=0.05)
corrected model	7	3.257	0.032
intercept	1	14.21	0.002
altitude	2	5.85	0.015
rainfall	2	1.14	0.351
Altitude*Rainfall	3	0.47	0.707
Error	13		
R-squared	0.637		

CONCLUSION AND RECOMMENDATION

A total of 7046 ticks were collected, of which 69% in the mid zone, 18.7% in the lower zone and 12.3% in the upper zone. Five different species were identified in this study and these are *Rhipicephalus appendiculatus* (96.8%), *Boophilus decoloratus* (1.5%), *Amblyomma variegatum* (1.3%), *Rhipicephalus compositus* (0.3%) and *Ixodes ricinus* (0.01%). This study showed that in agro-ecological zones of Rwanda, the distribution of ticks is different and is largely predominantly influenced by altitude and rainfall patterns. Heavy rains have a negative effect on tick populations in under high altitudes through its effect on ambient temperature while the converse is true for low altitude zones. In the mid altitude region, characterized by rainfall of between 1100mm and 1250mm, the rains have a beneficial effect on the population of ticks. According to study findings, ticks prevalence was highest in this zone (69%) and this could also be linked to host abundance. In the low altitude zone, with low rainfall of 900mm per year and average temperatures of 21 °C, the tick population decreases compared to the mid altitude zone. Tick control programs in Rwanda need to take into account variations in altitudes and rainfall in the different regions of the country.

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