INFLUENCE OF HABITAT TYPES IN TICK DISTRIBUTION: A CASE STUDY OF CENTRAL SERENGETI NATIONAL PARK

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ABSTRACT

Ticks are important vectors of disease-causing pathogens of humans, wildlife, and livestock, reducing tick abundance is an important but elusive goal this is because of their range of distribution. However, previous studies typically did not investigate factors known to affect changes and survival of tick populations and distribution in different habitat types within Serengeti national park. This study was conducted in central Serengeti National Park. Data were collected through the use of drag cloth but also the active search conducted through the use of square quadrat on five established transects in each habitat type. Microsoft Excel was used to analyze and establish the mean tick abundance while ANOVA single factor was used to test the hypothesis. A high abundance of tick species was observed in the woodland savanna followed by the Riverine habitat and lastly in open savanna grassland. Shannon wiener index revealed that riverine habitat had a diversity of (H'=1.75). followed by woodland savanna (H'=1.72) and lastly open savanna grassland (H'=1.27), By using One-way ANOVA found a significant difference in species diversity by ($P \leq 0.001$). The distribution of Amblyomma gemma, Amblyomma lepidum, Hyalomma impeltum, and Rhipicepharus sp which were common to all three habitat types with Rhipicepharus pulchellus, Rhipicepharus pravus, Hyalomma spp found in woodland and savanna and riverine habitat and Hyalomma rufipes which was found only in only Riverine habitat.

Finally, the use of Pearson correlation Analysis (PCA) on environmental parameters revealed that humidity (P=0.764e-04) strongly correlated to the high species, and temperature (P=2.19e-13) correlated strongly to low species diversity in the area. Tick control measures should consider the nature of the habitat which will allow tick control based on their distribution in a respective habitat where the common method for tick control such as the use of prescribed burning can't work.

Keywords: Distribution, Tick Density, Buffalo, Climate Variation, Wildlife Diseases.

INTRODUCTION

BACKGROUND INFORMATION

Over the past decades, tick-borne diseases have become a growing public health problem in Europe and other parts of the world (Süss et al., 2008) but also Tick-borne diseases are known to be ubiquitous worldwide field (Stanley, 2016)

Ticks are distributed across the world from the tropics to subarctic regions, with the greatest species diversity in the tropics and subtropics(Narasimhan & Fikrig, 2015), which results in a high mortality rate of livestock due to tick-borne diseases in Africa including Tanzania. Ticks comprise at least 866 species in two major families namely ixodid ticks (hard ticks) with 683 species and Argasid ticks (soft ticks) with 183 species (Jongejan& Uilenberg, 2004)**.** Ticks are known to have both indirect and direct effects on the host, indirect effects include transmission of tick-borne pathogens which are the causative of tick-borne diseases. Ixodid ticks transmit a wide range of tick-borne pathogens such as *Rickettsia, Ehrlichia (Cowdria), Babesia bigemina, Anaplasma and Theileria spp* while pathogens transmitted by Argasid include *Borrelia spp, and Aegyptionella spp*(Jongejan & Uilenberg, 2004). In the tropic regions, ticks transmit a greater variety of infectious diseases than any other arthropod vector (Jongejan & Uilenberg, 1994).

Ticks distributions are rather sensitive to even small changes in environmental conditions and respond differently to various habitat types(Rogers & Randolph, 1993). The population and ecology of ticks are fundamental to the spatial and temporal variation in the risk of infection by tick-borne pathogens(Randolph, 2004).

The popular, but rarely documented view is that ticks have increased in distribution and abundance over recent years field (Scharlemann et al., 2008). It has long been felt that various environmental factors play an important role in the distribution and abundance of this noxious pest. Types of vegetation and more specifically, the environmental conditions created by these different habitats have been of major concern(Dobson, 2018).

Rogers & Randolph, (1993) argues that the numbers of ticks found within a particular area generally depend on the physical makeup, biological factors, and environmental variables of existing vegetation. Tick populations are spatially extremely heterogeneous and highly variable in abundance and distribution depending on habitat type, conditions, and composition over time (Scharlemann et al 2008), moreover, the basic requirements for the well-being of ticks is changing for the worst in many areas.

PROBLEM STATEMENT

The tick transmits a wide range of pathogens of both medical and veterinary significance(Estrada-Peña, 2003), ticks may have direct effects on animals as blood-sucking parasites, causing anemia, weight loss, damage to skins and hides, protozoa and toxins which weaken animal health and ultimately lead to animal death (Kaufman, 1989).

Despite ticks having diverse impacts on wild animals, their response tends to vary differently concerning habitat types (Rogers & Randolph, 1993). However, previous studies typically did not investigate factors known to affect changes and survival of tick populations and distribution across different habitat types within Serengeti national park such as host abundance, microclimate, and vegetation structure.

Therefore, due to such a gap in knowledge about tick distribution in different habitat types within Serengeti national park, this

study aimed at assessing Tick population distribution and interacting factors that potentially affect tick abundance across different habitat types.

JUSTIFICATION

Results from this study provide Knowledge on habitats more prone to high tick populations and allow conservationists to predict how the vector's distributed in different habitat types, but also knowledge of tick abundance provides useful information for long-term monitoring of tick population dynamics within Serengeti National Park.

GENERAL OBJECTIVE

To determine the influence of habitat types in tick distribution.

SPECIFIC OBJECTIVES

1. To determine the abundance and diversity of ticks in different habitats.
2. To compare tick species diversity in different habitats
3. To determine the influence of environmental attributes on ticks' distributions in different habitat conditions and composition

STUDY HYPOTHESES

1. There is a significant difference in tick species diversity and abundance in different habitat types in central Serengeti National Park
2. Habitat types have a significant influence on the abundance and diversity of tick distribution within central Serengeti National Park.

METHODOLOGY

STUDY AREA DESCRIPTION

This study was conducted at central Serengeti (2"26'S, 34"48'W) within Serengeti National Park with an area of 14,763 sq km (5,700 sq miles) which is located in north-west Tanzania, annual precipitation is between 833mm per year at the eastern end of the park and 900 mm in the central and western parts. Soils are generally well drained and moderately infertile(Schmidt, 1975). Annual average temperature (16-25 °C) decreases from southeast to North West. The distribution of precipitation is bimodal with short rains starting from early November to December and long rains starting from January to March (Kru, 1997). The altitude varies between 240 and 1609m above sea–level. The central Serengeti National Park possesses a variety of habitat types of Open savanna grassland, Riverine Forest, and Woodland savanna where the study was conducted.

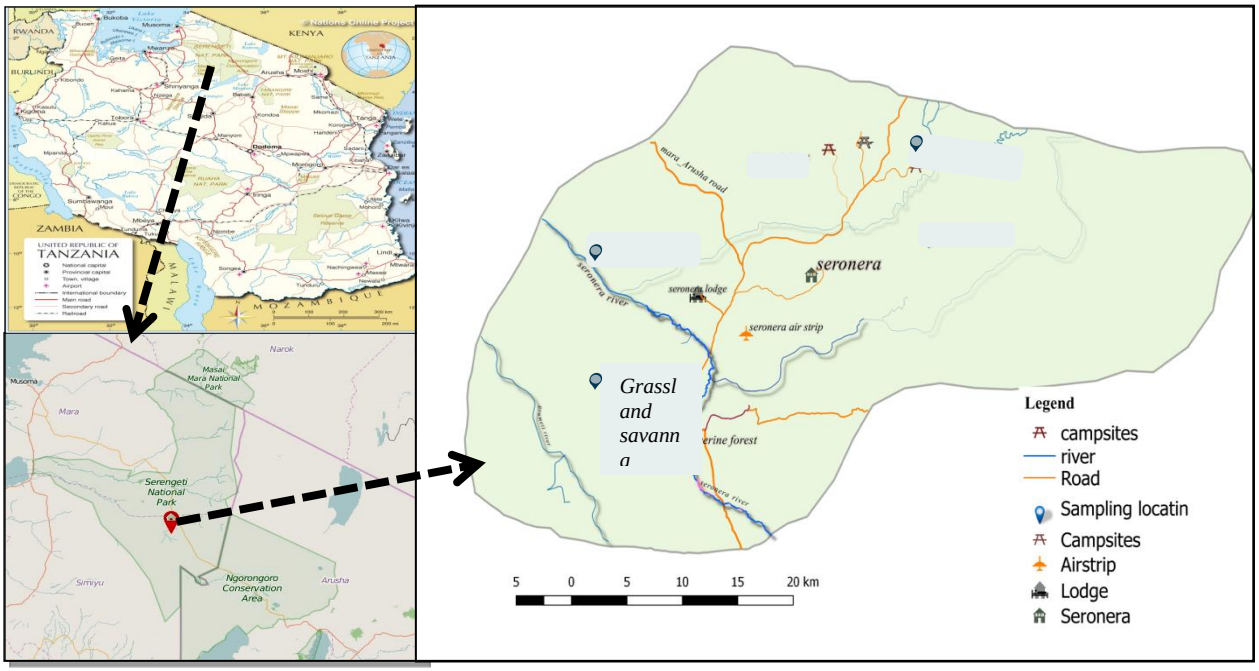

Figure 1: Map of Central Serengeti National Park showing the three sampling locations (Source: Quantum GIS and Google Earth Pro 2019)

SAMPLING DESIGN AND DATA COLLECTION

SAMPLING DESIGN

Tick sampling in each habitat type was conducted by establishing 5 transects of 200m each using GPS coordinates, stake**s,** and other objects were used to mark the start and end points of each measured length of the transect this procedure was repeated in all habitat types namely Open savanna grassland, Riverine habitat, and Woodland savanna**,**

Transects contained 15m wide with 5m from one transect to another also transects were established at 20m from the road to avoid the edge effect (for the habitat types found along with the road network).

On each habitat type ticks were collected from the vegetation by using the square quadrat method and a piece of cotton toweling trap which mimics a host (Fyumagwa et al. 2007). Removal sampling(quadrat method) for adult ticks and drag sampling(cotton toweling trap) for immature ticks (larvae and nymphs) as previously described by Short & Norval, (1981), were used. Environmental variables within different habitat types were recorded including temperature and humidity but also the assessment of biotic factors, such as predominant vegetation and animals within the sampling locality were recorded. Transects were surveyed from 11.30 am to 2.30 pm when vegetation was dry and ticks are active for attachment into a host the procedures were repeated for 14 consecutive days.

SAMPLING TECHNIQUE

QUADRAT METHOD: ADULT TICK COLLECTION

Removal sampling of adult ticks was done by throwing a meter square quadrat randomly within each of the 5 transects of

200m diameter. Thereafter, ticks that were found within the square were collected and stored separately in 10 ml labeled vials with 70% ethanol. Each sampling transect was visited twice during the data collection period. Also, to have great precision on the data, the meter square quadrats were repeatedly thrown ten times within each transect (CDC, 2018).

PIECE OF COTTON FLANNEL STRIPS: IMMATURE TICK COLLECTION

Immature ticks particularly larvae and nymphs were collected by using the 'drag-sampling' method. This method refers to the dragging of a piece of cotton towel at a constant speed over the pasture which mimics the host (Walker et al. 2003). The short end of a $1m^2$ sheet of white flannel cloth is stapled to a wooden rod which had a three feet long rope attached to each side, forming a handle (Stanley, 2016), and the trailing edge may be cut into "small fingers" rather than using a solid cloth (Rulison et al., 2013). The cotton flannel was then pulled over the grass and underbrush where ticks would grab onto the soft fabric since ticks engage in a behavior called questing, where they climb some short distance off the ground onto some brush, or grass and "wave their legs as a potential host approaches" (Carroll & Schmidtmann, 1992). This allows the tick to easily grab onto the trap which will act as a host where the tick is perched.

Drag was repeated ten times and was inspected at regular intervals of 25 m=30 seconds, the drag was examined and the tick was removed using forceps then after being collected ticks were placed into labeled vials for further identification, in each of the 15 transects of 200m diameter

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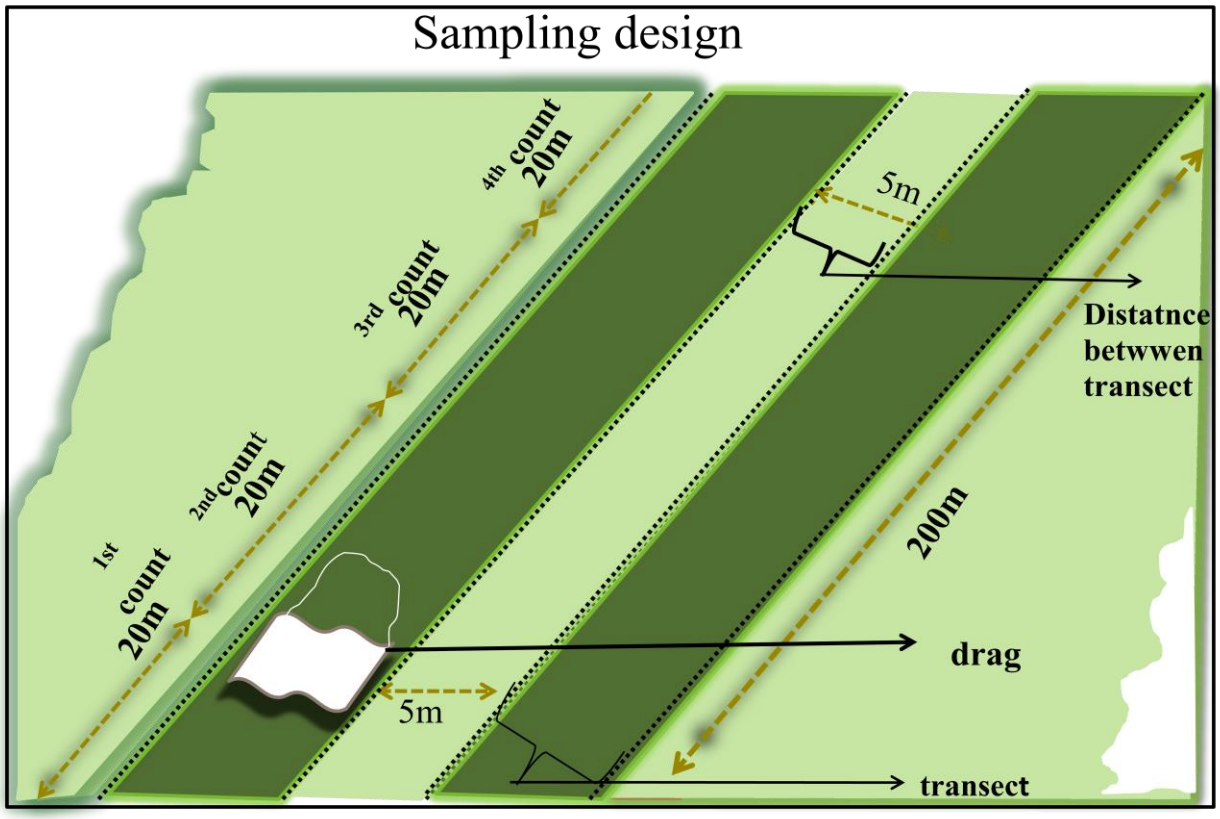


Figure 2: The sampling design along with habitat type employed at each sampling transects**.**

Species identification

The ticks from each habitat were collected and preserved in separate labeled vials with 70% alcohol, and later counted and identified to genus and species level using a standard lens with the aid of an identification guidebook by Walker et al. (2003), and consultation with the veterinary doctor of Serengeti National Park.

DATA ANALYSIS

IDENTIFICATION BOOKS

All the collected tick species were identified by the use of field guidebooks.

SHANNON WIENER INDEX

For the calculation of species diversity, the Shannon-Weiner index method was applied. This method provided important information about the rarity and commonness of the species in all three habitat types (Shannon & Wiener, 1948). Before the calculation of the Shannon Wiener index, data were inputted into the Microsoft Excel software to compute in the readable format (CSV) then VEGAN was plugged into R-studio ready for calculation of species diversity H' and species evenness J. This method helps to provide important information about the peculiarity and commonness of the species in those sampled areas independently(Schelt& Villa, 2017)

ANALYSIS OF VARIANCE (ANOVA)

After determining the species diversity, ANOVA was used to compare mean

differences between groups in the three habitat types namely Open savanna grassland, Riverine habitat, and woodland savanna. This method was used to analyze the differences between group means, the predictor variable for this research (x variable) was environmental parameters, while the response (y variable) will be the tick diversity (Lin, & Sleigh, 2016).

PEARSON'S CORRELATION ANALYSIS (COEFFICIENT OF DETERMINATION)

This analysis was used to show correspondence between ticks' species density as a response variable and environmental parameters as explanatory variables (Cajo J. E &Verdonschot F.M,1995).

RESULTS

TICK SPECIES DENSITY AND DIVERSITY

A total of 628 individual ticks were collected of which 427 individuals were collected from the Riverine habitat belonging to 8 species, 172 individuals were collected from the woodland savanna with 7 species, and 29 individuals were collected from the Grassland habitat belonging to 4 species. However, a total of 4 species were found in all three habitats. The most abundant tick species were *Amblyomma gemma* and *Hyalomma* which had 151 individuals each followed by *Amblyomma lepidum* (n=121), and the least was *Hyalomma spp* (n=24) (Table 1).

Table 3: Tick species density and diversity indices Ticks' species density

The tick density in the three study sites was 0.028, 0.0011, and 0.002 in woodland savanna, riverine habitat, and open savanna grassland respectively. (Fig 3).

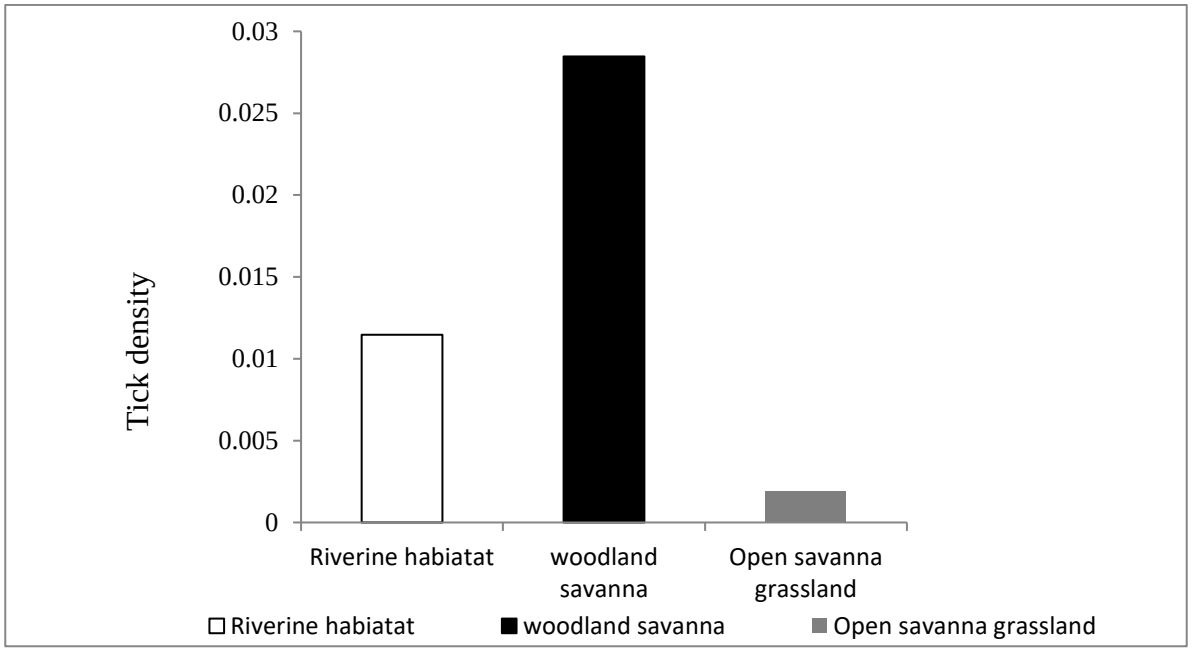


Figure 4: Tick species density in three habitat types

Tick species diversity

Results from Shannon Weiner Index showed that the Riverine habitat had more species diversity (H'=1.88) followed by Wooded grassland (H'= 1.71) and the last one was Grassland Savanna (H'=1.27) (Figure 4). ANOVA test showed that there were significant differences in species diversity amongst the three habitat types (P< 0.01).

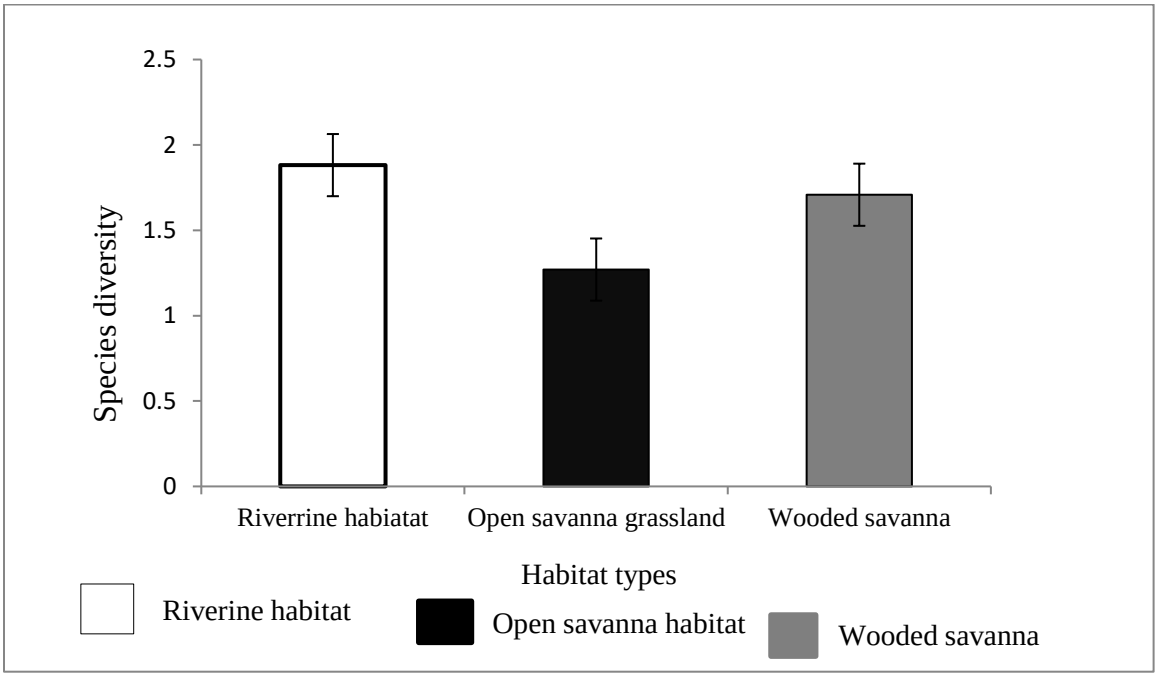


Figure 5. Represent comparison of tick species diversity in different habitat types and the lines represent standard error

Environmental Attributes on determining tick's species distribution

Measurements of two environmental attributes namely temperature and precipitation revealed that Savanna grassland had both the highest mean temperature (23.3C) and precipitation (864.8 mm) compared to the other two habitats (woodland and riverine) (Table 2).

Table 1 Overview of the key drivers that tend to affect tick distribution with respect to habitat

KEY DRIVER	Environmental attribute	Savanna grassland	Woodland savanna	Riverine habitat
Climate	Temperature (Celsius)	23.3	22.6	19.1
	Precipitation (mm)	864	883.5	897.75
Ecological/ geographical factor	Habitat structure and composition	Plain savanna grassland vegetation	Wooded vegetation	Mixture of scattered wooded vegetation with short and tall grasses
Biological	Host dispersal	Scattered animals i.e. Topi, zebra, impala, hartebeest	Solitary and small groups of animals such as Buffalo, Giraffe	Small groups of animals such as wildebeest, Zebra, Topi but also buffalos

PEARSON'S CORRELATION ANALYSIS

Pearson's Correlation Analysis (PCA) revealed that species diversity is negatively correlated with temperature (r= -0.9687346) and positively correlated with humidity (r= 0.9786208) (Fig. 5).

Linear model(simple liner regression) was used to show the relationship between temperature (explanatory variable) and species diversity (response variable) ($R2=0.9094, p<0.001$)which showed a negative relationship whereby the increase in temperature resulted in to decrease in species diversity (figure 5) but also showed the relationship between humidity (explanatory variable) and species diversity (response variable) ($R2=0.9717, p<0.001$)which showed positive relationship whereby the increase in humidity resulted to increase in species diversity(Figure 6)

Figure 6: A linear model shows the effect of humidity on species diversity in all three habitat types

The temperature was negatively correlated to low tick species diversity in all three habitats. The negative correlation means as temperature increases the species diversity in all habitat types was decreasing (Oksanen, 2016).

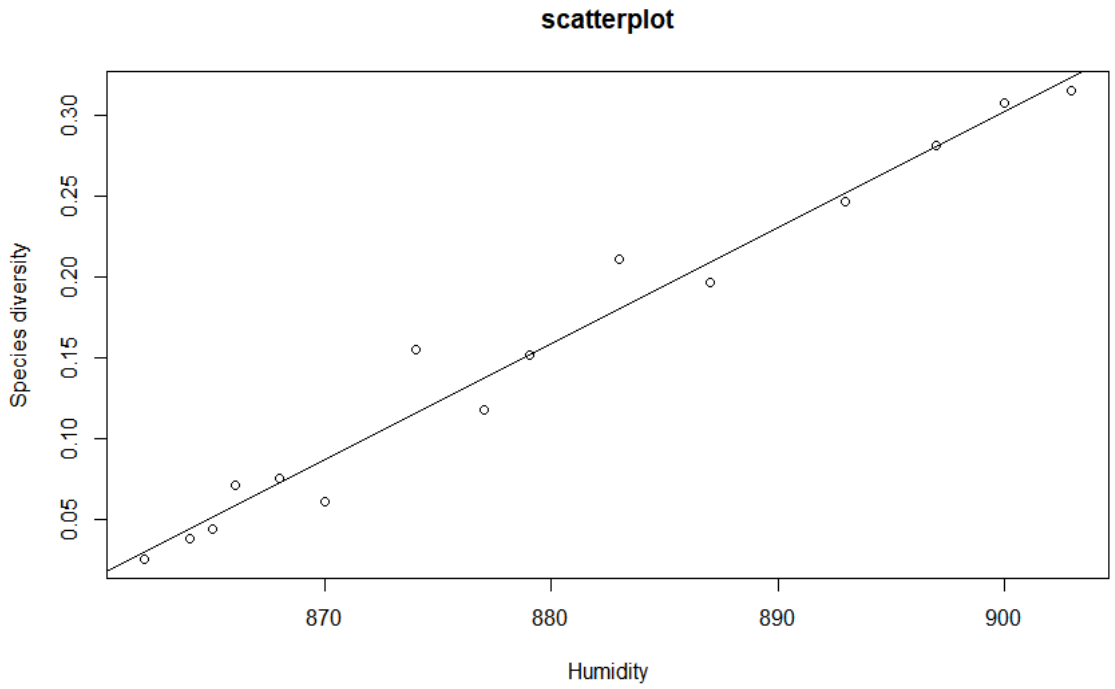
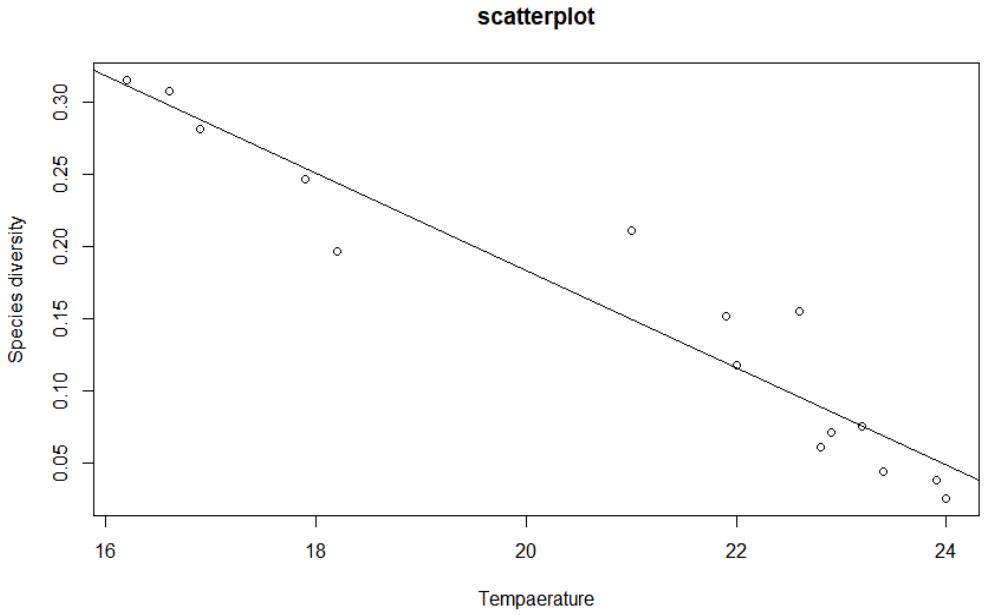
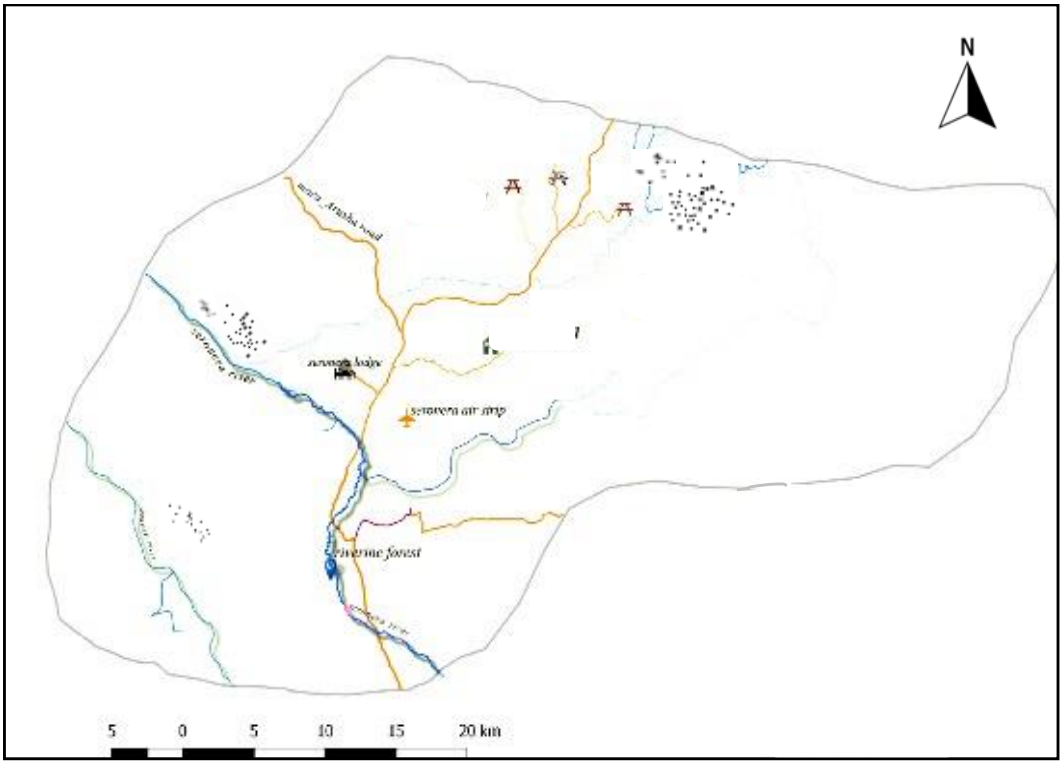


Figure 7: The linear model of temperature on species distribution to all three habitat types





1.1.1. Tick distribution

Figure 8. Tick distribution, common four species in all three habitats; *R pulchellus* ( ); *R Pravus* ( ); *H. rufipes*(▼), *Hyalomma spp* ( )

Table 2. Tick distribution in terms of their composition in different habitat types (* More than 25%, **more than 10%, *less than 10%)**

Tick species	Riverinehabitat	Woodland savanna	Open savanna grassland
Amblyommagemma	**	***	***
Amblyommaspp	**	**	***
Hyalommaimpeltum	***	***	***
Rhipicepharusspp	**	**	*
rhipicepharuspulchellus	*	*	
Rhipicepharuspravus	*	*	
Hyalommarufipes	*	*	
Hyalommaspp	**		

DISCUSSION

This study focuses on the habitat characteristics of tick distribution and their diversity in central Serengeti. The variations in biotic and abiotic variables governing the environment were used to analyze changes in the habitat of individual species amongst the three habitat types sampled. The favourable climatic conditions for survival and multiplication are cool moist places, but they can tolerate relatively arid conditions. The presence of favourable temperature, humidity, and appropriate hosts are known to be important factors for the tick distributions.

TICK SPECIES DENSITY

The findings from this study showed woodland savanna had more tick species density compared to the Riverine and grassland habitats. This could be due to the high presence of host species such as buffalo in the area. Some of the species are abundant and only found in woodland savanna since species like *Hyalomma rufipes* are buffalo host specific Walker et al (2003), however indirectly density of tick hosts may be reflected by the availability of food resources for their survival (i.e., vegetation) the amount of shade and protection provided by the vegetation during daytime

Woodland vegetations provide a cool climate for tick survival compared to open savanna grassland where temperature becomes very high temperature and low amount of humidity. The findings are in line with the study by Kerario et al., (2017), Hatem et al., (2018), and Randolph, (2016) who noted that tick abundance tends to vary with the variation in habitat conditions like temperature and humidity.

TICK SPECIES DIVERSITY

Significant differences in tick species diversity among different habitat types were detected. In the open vegetation types, there were generally few ticks, whereas in the wooded areas tick abundance was generally greater (Figure 3). Ticks are sensitive to desiccation, and in an open field, they will

be strongly exposed to the desiccating effects of both sun and wind(Kerario et al., 2017). It is interesting to note that almost all ticks recorded in open fields in this study were recorded close to the acetones' where ticks find shadow or shelter during most of the day, or under small shrubs where the ticks could also obtain protection from sun and wind (Walker et al. 2003).

But also diverse species of wild animals frequently migrate to nearby riverine habitats for water Fields(Scharlemann et al., 2008). Thus, high tick species diversity has occurred due to host dispersal in the riverine area also riverine habitat provides cool weather of the area which provides a cool climate for different tick survival.

ENVIRONMENTAL ATTRIBUTES IN TICKS DISTRIBUTION

Environmental attributes assessed in this study as temperature and precipitation which was part of this study. A specific habitat type has been characterized by different environmental conditions as a study site found that the Riverine habitat was characterized by low temperature with high humidity, Results from the coefficient of determination (Pearson's correlation) revealed that temperature tends to affect negatively tick distribution in such a way that in Riverine habitat had more species diversity since due to low temperature and high humidity which provides the cool environmental condition for tick survival unalike to open savanna grassland which characterized by high temperature and low humidity which leads to less abundance and diversity where ticks can be exposed to desiccation effect this findings are in line with Oksanen, (2016) gave the interpretation that, the low the temperature the high the species diversity but also the wide range of tick distribution which met the findings of this study.

STUDY LIMITATIONS

This study was limited by several factors the main limitation was the limited amount of time provided for data collection where the time provided a limited chance to collect enough data based on tick quantifying tick occurrence but also limited resources including a vehicle for traveling from one study habitat to another

CONCLUSION

The study managed to identify how habitat types and their condition on influencing tick distribution and their occurrence. Many factors are involved in tick distribution either positive or negative the drivers can be those directly related to the nature of the habitat, those related to changes in tick host distribution particularly buffalo, and other ecological changes such as, the physical makeup of the habitat these factors are interlinked to each other on influencing ticks' distribution in respect to habitat

RECOMMENDATION

Tick control measures should consider the nature of the habitat which will allow tick control based on their distribution in a respective habitat where the common method for tick control such as the use of prescribed burning can't work. Also, this study ascertained the broad variety of tick species, most of each is of veterinary importance. The presence of each tick species is correlated with the potential occurrences of tick-borne diseases and suggestions for tick control in the area are considered. More studies on ticks should be done determining which kinds of animals

are highly affected by ticks based on the level of vegetation but also Determining tick species that carry and transmit pathogens to wild.

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