Tick Community Structure along Edge Habitat in Swaziland

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Introduction

Sub-Saharan Africa stands to drastically increase in human population over the next several decades (Gerland et al. 2014). Undoubtedly human impacts on the landscape in this region will intensify. With a growing need for food resources, agricultural development onto savannah will increase, causing significant impacts on the organisms inhabiting the landscape. Some of these organisms yield significant impacts on agricultural production and human health. It is, thus, important to understand how these organisms may occur along edges of agricultural patches and savannah.

Agricultural patches and savannah of the landscape are different habitat types for organisms. Each habitat type possesses different available resources and cover for organisms of different taxa. The number of unique habitat types present on a landscape, the respective proportions of those habitat types that comprise the landscape, and the spatial arrangement of those habitat type patches, may yield significant impacts on biodiversity (Fahrig et al. 2010). These factors also create edge habitat. Edge habitat is essentially the boundary at which two patches of unique habitat types converge. Edge habitat can cause edge responses in organisms. A species' edge response can occur as a result of ecological flows or changes in habitat permeability, access to separated resources, resource mapping, and species interactions (Ries et al. 2014). Different taxa can resultantly occur at differing distances from edge habitat.

Hard-bodied (*Ixodidae*) ticks are a particularly important group of organisms to study edge response. Ticks possess three distinct life stages – larvae, nymph, and adult (Walker et al. 2014). Each life stage possesses different movement and subsequent dispersal abilities. These three distinct life stages can occur in differing proportions away from an edge. Lawn habitat was comprised of horticulturally-planted grasses and had a low percentage of canopy cover. Host-seeking ticks that occurred on lawn habitat were most often found within one meter of lawn-forest edge habitat. Different host-seeking tick life stages select different habitat types and can occur in different proportions across a landscape (Stafford and Magnarelli 1993). An important motivation for tick movement is avoiding desiccation, which is the most common cause of mortality aside from predation (Rogers and Zolnik 2007). Ticks will become restless and move frequently when continuously exposed to dry air, but will rest and become static in humid air (Lees 1948).

Due to pilot data collected at the proposed study sites, I expected most of the ticks encountered to either be *Amblyomma hebraeum* or *Rhipicephalus* genus. I also expected to encounter *Boophilus*, *Haemophysalis*, and *Hyalomma* genera, although less frequently (Cumming

1998, Cumming 1999). The Lowveld Ecosystem provided a unique opportunity to study how different genera and life stages of ticks occur along edge habitat. Ecological flows and different habitat permeability between unique habitat types may affect movement of host-seeking ticks by promoting or negating their ability to permeate different habitat types through edges.

I predicted that adult life stage ticks will occur in highest density and abundance in close proximity to part-savanna edge habitat. Adult life stage ticks exhibit increased tolerance to desiccation and can occur along edge habitat where they may experience larger-bodied potential host organism. I also predicted that larvae and nymph life stage ticks will occur in highest density and abundance within the savanna habitat type, and that they will occur farther distances away from edge into the savannah. These two earlier life stages are more at risk to desiccation and attach to potential host organisms more opportunistically.

Methods

Sampling was conducted during the austral winter season from 14 June, 2017 until 25 July, 2017. All eight edge habitat sites occurred within the greater Lowveld Ecosystem in the Kingdom of Swaziland, Southern Africa. We identified eight edge habitat sites to sample. Each edge habitat site was sampled for four continuous days. There were two different types of edge habitat sites, and there were four replicates of each type. Each edge habitat site type consisted of two of three different landscape usages. The first type of landscape usage was savanna conservation area. The second type of landscape usage was sugarcane agricultural area. The third type of landscape usage was communal human living area. Thus, edge habitat sites either consisted of savanna conservation area and sugarcane agricultural area landscape usages, or savanna conservation area and communal human living area landscape usages.

We drove from Mbuluzi Game Reserve to each of our edge habitat sites. We organized three paired transects upon arriving at each edge habitat site. For each paired transect in each edge habitat site, one transect traversed savanna conservation area, and one transect traversed sugarcane agricultural area or communal human living area. Tick flagging surveys were conducted parallel to the boundary formed by each landscape usage converging, henceforth referred to as the edge boundary. Tick flagging surveys (Ginsberg and Ewing 1989) were conducted at 10 meter intervals moving away from the landscape usage boundary. Tick flagging surveys were conducted 10 meters away from the transect in both directions which ran parallel to the landscape usage boundary (Figure 1). Several transects were spatially restricted to <100 meters in length. While sampling from these transects we conducted fewer flagging surveys, but increased flagging survey length so that 200 meters were surveyed on every transect. This ensured that the same effort was put into sampling per transect across each site. Sampling was conducted simultaneously and within a one-kilometer proximity to other University of Florida-associated research projects also examining edge responses in varying wildlife taxa. These other research projects did not affect tick flagging surveys, but they did opportunistically provide additional host-seeking tick specimens for future pathogen analysis.

Each of the eight edge habitat sites possessed differing spatial features. Each of the three transects laid out per edge habitat site also possessed differing spatial features. Recognizing these differences allowed us to determine how far host-seeking ticks were sampled from edge boundaries. They also allowed us to quantify spatial features which allowed us to identify potential outliers in our data.

Tick flagging surveys were conducted with 1X1 meter cotton cloth. A 1X1 meter cloth will henceforth be referred to as a flag. For each tick flagging survey conducted, the flag was dragged across the top of vegetation repeatedly for a distance of two meters. The flag was then checked visually for host-seeking ticks. This process was repeated every two meters until the tick flagging surveys reached their respective terminal ends away from the transect. When a host-seeking tick was found on a flag, that host-seeking tick was removed from the flag. That host-seeking tick was then placed in a 100% molecular-grade ethanol-filled vial. Vials were labelled by their respective edge habitat site, landscape usage, transect number, and tick flagging survey number. Host-seeking ticks stored in vials were returned to the Savanna Research Center Lab within the Mbuluzi Game Reserve for genus-level identification and cataloging at the end of each sampling day. Host-seeking ticks found on the same tick flagging survey location were later consolidated into the same storage and transport vial.

Host-seeking ticks were identified to the genus-level using *Ticks of Domestic Animals in Africa: a Guide to Identification of Species* (Walker et al. 2014). During identification, host-seeking tick specimens remained saturated in 100% molecular-grade ethanol solution to ensure integrity of the specimen. The host-seeking tick specimens were then packaged and mailed to Dr. Samantha Wisely and Dr. Katherine Sayler from the University of Florida Wildlife Ecology Department. Importing arthropod specimens into the United States is legal under two conditions. The specimens must be preserved in pathogen-deactivating solution. The specimens must also be imported with the purpose of being used in research. Both of these criteria were met by this study. Dr. Wisely and Dr. Sayler identified respective host-seeking tick specimens' species. Dr. Wisely and Dr. Sayler also conducted additional analysis on each respective host-seeking tick specimen in order to determine whether or not any were infected with tick-vector pathogens present in the sampling region, such as Ricketsia. The dataset generated by this study and the aforementioned host-seeking tick specimens will also be used by Ms. Kimberly Ledger for her Ph.D work with the University of Florida Wildlife Ecology Department.

The dataset generated by this study was recorded in Microsoft Excel. Data was recorded and updated daily, and Excel files were saved within a minimum of two separate hard drives to insure proper data management. Microsoft Excel was used for preliminary data analysis. Preliminary Microsoft Excel data analysis consisted of creating pivot tables and graphs to examine differences in where different demographic life stages and genera of host-seeking ticks occurred in relation to landscape usage boundaries. Program R (R Core Team 2015) was also used for data analysis. Program R data analysis consisted of two main analyses. The first analysis used the VEGAN (Vegetation Analysis) package to determine differences in tick community structures between the two different edge habitat types. Subsequent analyses used the VEGAN package to determine the differences in tick community structures between the three landscape usages. The second main analysis used the bbmle, lme4, and AICcmodavg packages to run mixed analysis. Distances at which ticks occurred from edges was the response variable. Results were presented at the University of Swaziland in Mbabane, Swaziland on 25 July, 2017.

Results and Discussion

We found that ticks occur primarily in savannah habitat type. All genera and all life stages of ticks select for savannah habitat type. Hamophysalis genus ticks occurred primarily in disturbed savannah habitat type (Figure 2). Rhipicephalus genus ticks occurred primarily in undisturbed savannah habitat type (Figure 3). Not enough Amblyomma genus ticks were sampled to derive any significant results. Different life stages of ticks did not appear to select for disturbed savannah or undisturbed savannah. Distance from edge did not prove to be a significant predictor for encountering different tick life stages, neither did distance from edge did not prove to be a significant predictor of *Haemophysalis* tick presence (Figure 04) nor *Amblyomma* tick presence. Distance from edge proved to be a significant predictor of *Rhipicephalus* tick presence (Figure 05).

There is also a significant need to understand where high abundances and densities of tick life stages and genera occur along edge habitat, because they are important vectors of several zoonotic diseases. Tick-borne diseases reduce annual agricultural yields of cattle-based products and endanger human health (Petney et al. 1987, Maupin et al. 1991, Ostfeld et al. 1995, Dlamini 1996, Ostfeld and Keesing 2000, Randolph 2004, Rajput et al. 2006, Keesing et al. 2010). Understanding host-seeking tick abundances and movements as they relate to habitat types may help future landscape management to reduce risk of tick-borne diseases. Informing landscape management may also increase the effectiveness of acaricide applications and reducing tick prevalences in key locations. Understanding the edge responses of ticks, may lead to other environmentally-sound means of controlling tick-borne diseases in the region (Lane et al. 1991). The 2018 IRES cohort will study the prevalences of tick-borne diseases in the region.

Figures

Figure 1: Demonstrates the schematic of transects and flagging surveys. Black lines represent the edge formed by the convergence of two landscape usages. Red lines represent the paired transects. Blue lines represent the flagging surveys. 200 meters of flagging surveys were conducted for each of the paired transects. Either 10 individual 20-meter flagging surveys, or eight individual 25-meter flagging surveys were conducted.

Figure 2: Haemophyalis primarily occur in disturbed savannah.

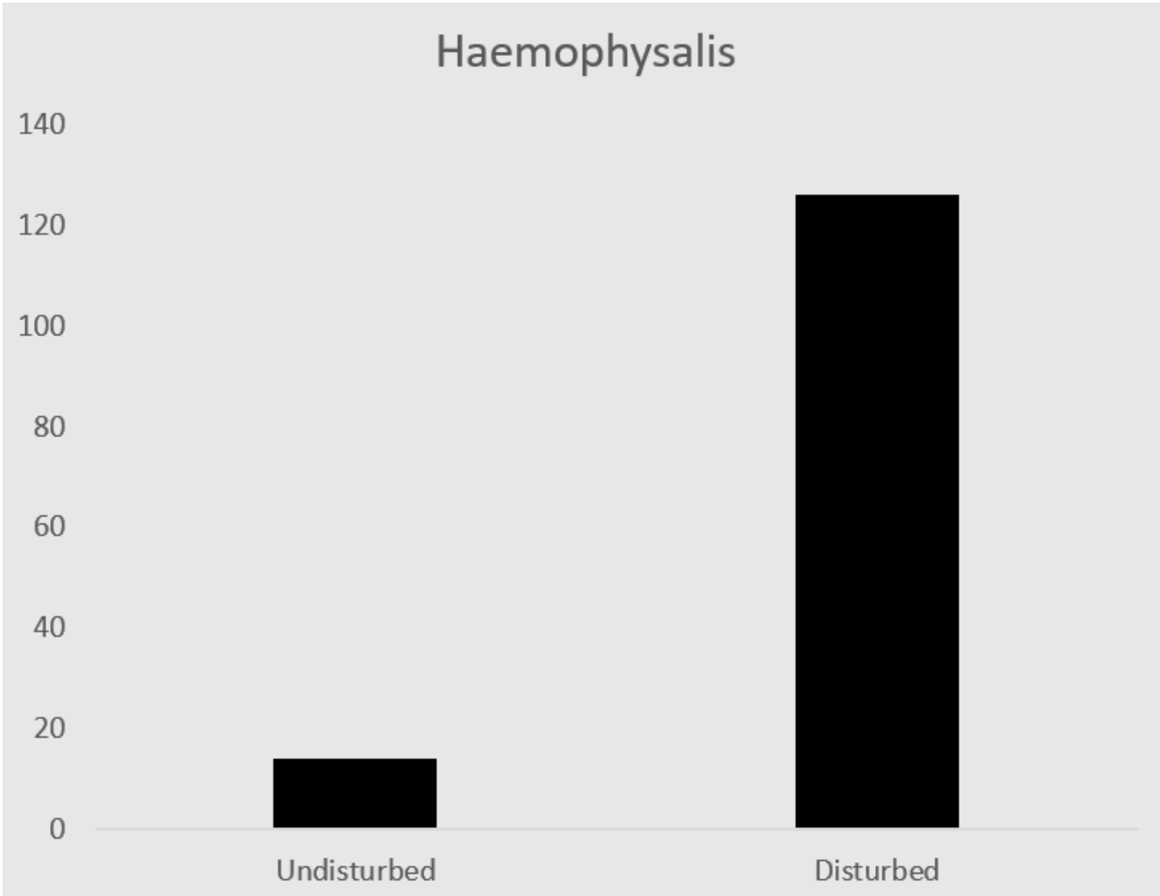


Figure 3: *Rhipicephalus* primarily occurred in undisturbed savannah habitat.

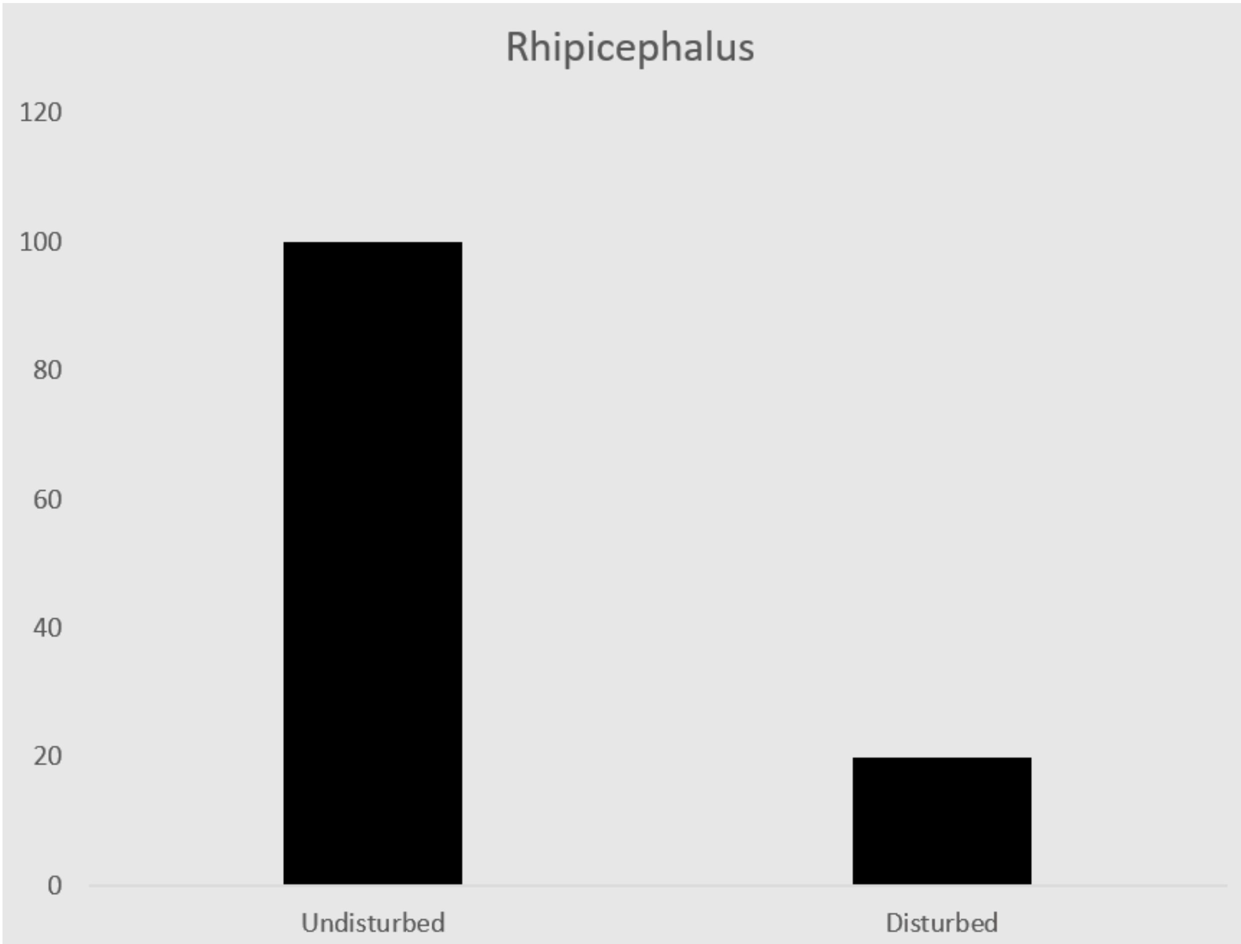


Figure 4: Distance from edge habitat is not a significant predictor of encountering *Haemophysalis* ticks.

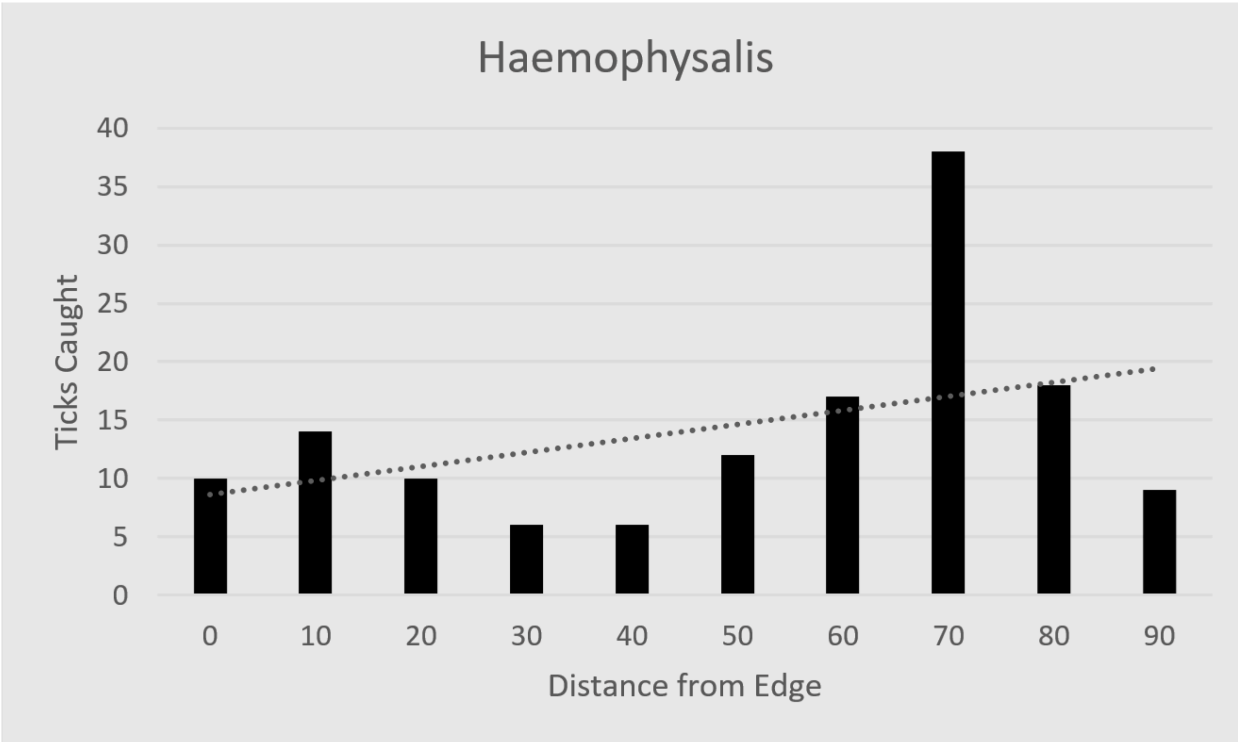
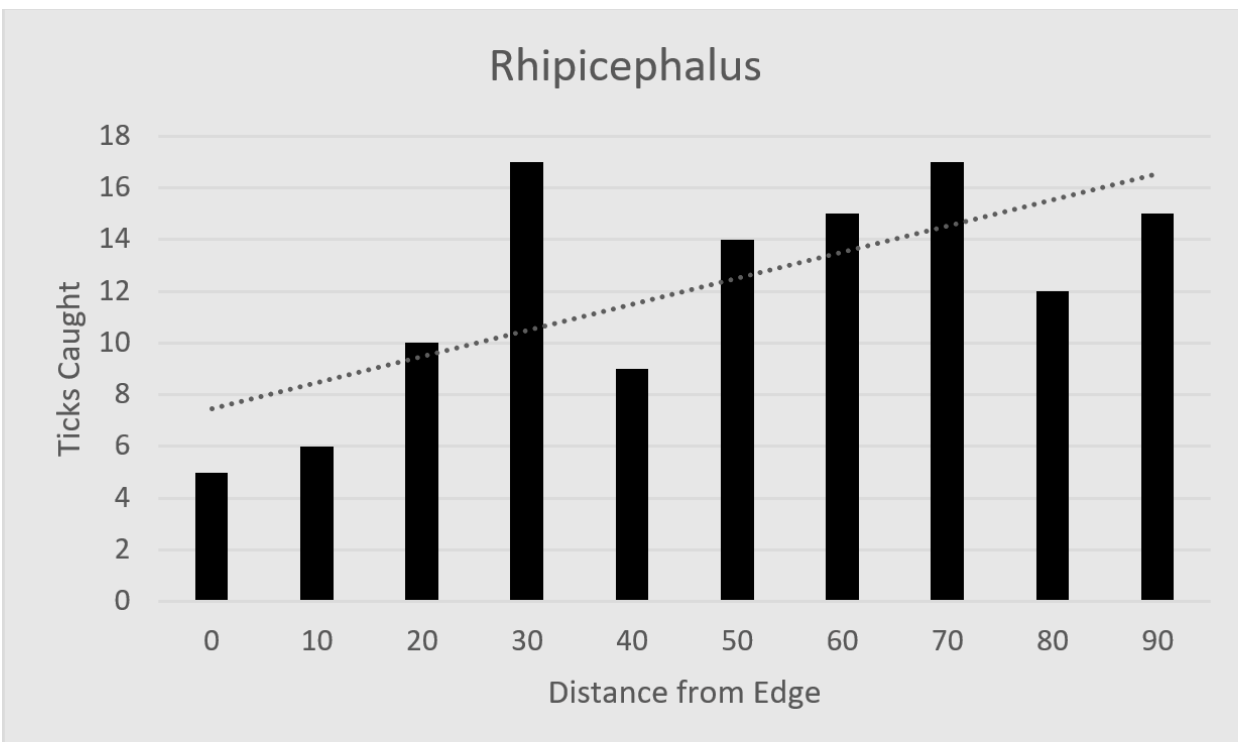


Figure 05: Distance from edge habitat is a significant predictor of encountering *Rhipicephalus* ticks. $P < .05$. Rhipicephalus ticks appear to avoid the first 20 meters from an edge.



<u>References</u>

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