Incorporating Climate Change in Spatiotemporal Species Distribution Models for cattle tick *Rhipicephalus (Boophilus) microplus*

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Abstract

During the last couple of decades, cattle ticks have significantly deteriorated the economy of southern cattle industry primarily in South American countries. In this work, we argue that a key variable of the sizable increase in the population of cattle ticks is due to climate change. We analyzed data from South American regions provided by AGROSAVIA (formerly CORPOICA) and analyzed the population growth of cattle ticks with a traditional species distribution model and compared it with a proposed model that incorporates climate change. Here, we present an analysis of the distribution of the *Rhipicephalus (Boophilus) microplus* in the Cundiboyacense Altiplano using static and dynamic modeling techniques that incorporate time, space, and climate conditions. We conclude that incorporating global temperature variations increases the accuracy of the spatiotemporal model. Our results support prior studies on cattle tick populations in Europe and Central America.

Introduction

Rhipicephalus (Boophilus) microplus is considered to be the most important tick parasite of livestock in the world [1]. *R (B) microplus* can be categorized as an introduced species and corresponds to a hematophagous ectoparasite which causes severe damage to its hosts (bovines) which begins with the dermal irritation of the host during the blood-feeding process, exposing it to harmful agents such as *Babesia bovis*, and *Anaplasma marginale*, which can develop strong infections leading to appetite loss, anemia, developmental delay, and strong fever in cattle (Babesiosis). In addition, *R (B) microplus* have zoonotic potential due to their ability to serve as vectors of serious diseases of domestic and wild animals [2].

Dataset and Methods

The technique of models based on agents and individuals represents the properties of the systems based on the adaptive behavior of individuals, which are treated as autonomous and discrete entities [3]. It focuses on the characterization of the discrete parts of the entities through rules of behavior, so that these entities interact with each other and with their environment. Space functions as a type of continuous modeling going through partial derivative equations and limiting the number of options that the agent has (individual movements) and allowing it to interact in multidimensional spaces [4, 3, 5].

A stochastic model based on agents and individuals was developed, with the purpose of understanding the spatial and temporal dynamics of the common tick of the *R (B) microplus* cattle in the Cundiboyacense Highlands. The model that represents the conditions of the Cundiboyacense Altiplano, the home range of *Bos taurus*, as a host species of this tick, the parasite's development states and the landscape configuration of the region (see Figure 1. The temporal and spatial dynamics of the host

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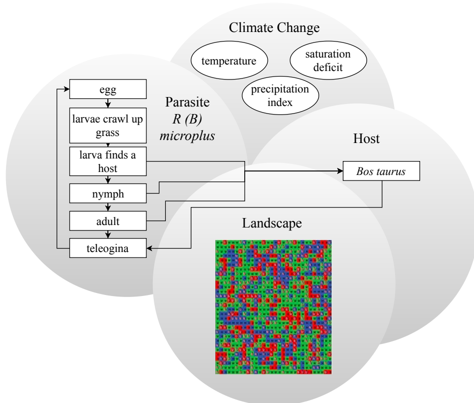

Figure 1: Conceptual model representing the interaction between climate change, landscape structure, the host and *Riphicephalus (Boohpilus) microplus* for the Cundiboyacense Altiplano.

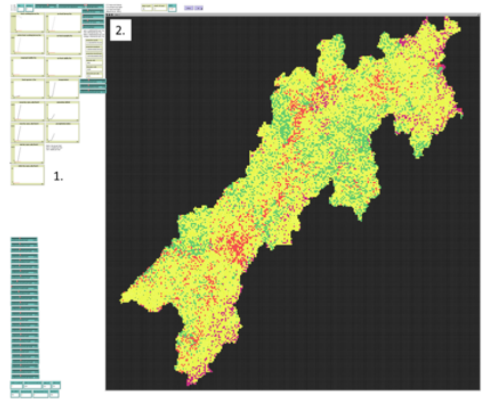

Figure 2: NetLogo interface where the processes of the population dynamics of *R (B) microplus* was developed. 1. Behavioral changes of the population during simulation; 2. Geographical space where the life cycle processes of *R (B) microplus* developed

were simulated, represented in density, The population structure of *R (B) microplus*, the parasite-host interaction through infestation for all stages of the life cycle of *R (B) microplus* and its spatial and explicitly modeled expression. The model was calibrated with landscape (habitat) and climate data from the Cundiboyacense Altiplano (described later in the inputs).

Results

We observed that population densities are similar for different stages of development. The larval and egg populations of free-living stages have weekly densities with maximum values of 200,000 eggs for the three factors and 150,000 ; With respect to parasitic stage, the maximum weekly values were maintained, 250 individuals for larvae, 100 for nymphs, and between 50-100 for adults on the host. We observed that populations decreased ending every year (week 52). Teleoginas, have similar population densities, there is no significant variation among meeting rates, the maximum value did not exceed 400 teleoginas throughout the simulation the three meeting factors. The above is supported by the Kolmogorov-Smirnov test, where for the states of free life there were no significant differences with p values between 0.97 to 0.99. With respect to parasitic states, significant differences were presented between parasite-host interaction rate (PHIR) 0.07 and 0.08 with $p = 0.0266$, which led to accepting the hypothesis of non-equality for these values; while for the PHIR 0.09 and 0.08 of this same state of development, there were no significant differences with $p = 0.1529$. On the other hand, because the data of nymphs and adults about the host presented a dense grouping, the statistical tests could not be applied to them.

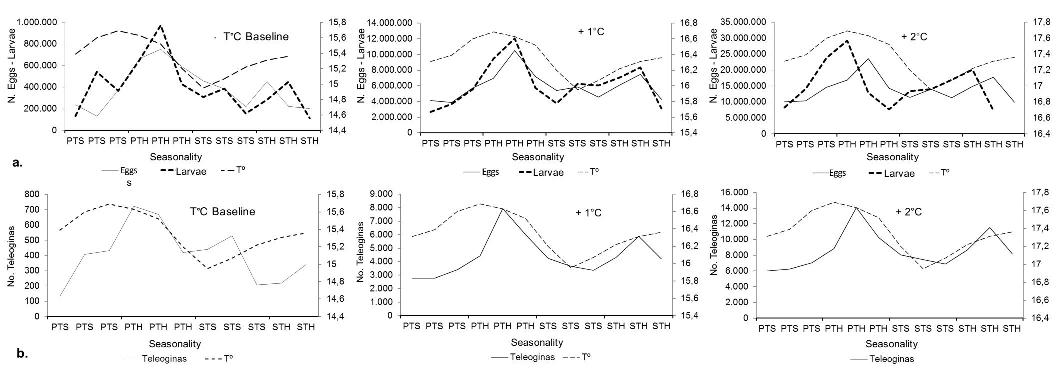

Figure 3: Population densities with respect to the climatic variables of precipitation and temperature independently. a. egg and larval stages b. teleoginas.

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