



Amblyomma ticks and future climate: Range contraction due to climate warming



Stefan Vilges de Oliveira^{a,b,c,*}, Daniel Romero-Alvarez^d, Thiago Fernandes Martins^e,
Janduhy Pereira dos Santos^f, Marcelo B. Labruna^e, Gilberto Salles Gazeta^c, Luis E. Escobar^g,
Rodrigo Gurgel-Gonçalves^h

^a Programa de Pós Graduação em Medicina Tropical da Universidade de Brasília, Campus Universitário Darcy Ribeiro, Asa Norte, CEP: 70910-900, Brasília, Brazil

^b Secretaria de Vigilância em Saúde do Ministério da Saúde do Brasil, Setor de Rádio TV Norte - 701 - Via W5 Norte, Edifício PO 0700, CEP: 70719-040, Brasília, Brazil

^c Laboratório de Referência Nacional em Vetores das Riquetsioses da Fundação Oswaldo Cruz, Av. Brasil 4365, Manguinhos, CEP: 21040-360, Rio de Janeiro, Brazil

^d Department of Ecology and Evolutionary Biology, University of Kansas, Lawrence, KS, 66045, USA

^e Departamento de Medicina Veterinária Preventiva e Saúde Animal, Faculdade de Medicina Veterinária e Zootecnia, Universidade de São Paulo, Av. Prof. Orlando Marques de Paiva, Cidade Universitária, CEP: 05508-270, São Paulo, SP, Brazil

^f Departamento de Geografia da Universidade de Brasília, Campus Universitário Darcy Ribeiro, Asa Norte, CEP: 70910-900, Brasília, Brazil

^g Department of Fish and Wildlife Conservation, Virginia Tech, Blacksburg, VAN, 24061, USA

^h Laboratório de Parasitologia Médica e Biologia de Vetores da Faculdade de Medicina da Universidade de Brasília, Campus Universitário Darcy Ribeiro, Asa Norte, CEP: 70910-900, Brasília, Brazil

ARTICLE INFO

Keywords:

Tick-borne diseases
Ecological niche modeling
Maxent
Spotted fever
Climate change

ABSTRACT

Ticks of the *Amblyomma cajennense* species complex are important vectors of spotted fever in Latin America. Environmental conditions determine the geographic distribution of ticks, such that climate change could influence the distribution of tick-borne diseases. This study aimed to analyze the potential geographic distribution of *A. cajennense* complex ticks in a Brazil region under present-day and future climate models, assuming dispersal limitations and non-evolutionary adaptation of these tick populations to climate warming. Records of *A. cajennense sensu stricto* (s.s.) and *Amblyomma sculptum* were analyzed. Niche models were calibrated using Maxent considering climate variables for 1950–2000 and projecting models to conditions anticipated for 2050 and 2070 under two models of future climate (CCSM4 and HadGEM2-AO). Broad suitable areas for *A. cajennense* s.s. and *A. sculptum* were found in present-day climate models, but suitability was reduced when models were projected to future conditions. Our exploration of future climates showed that broad areas had novel climates not existing currently in the study region, including novel extremely high temperatures. Indeed, predicted suitability in these novel conditions would lead to biologically unrealistic results and therefore incorrect forecasts of future tick-distribution. Previous studies anticipating expansions of vectors populations due to climate change should be considered with caution as they assume that model extrapolation anticipates that species would evolve rapidly for adaptation to novel climatic conditions.

1. Introduction

Ticks of the genus *Amblyomma* are important parasites of domestic animals and humans in the Neotropical region (Guglielmono et al., 2006). They are also the principal vectors of the zoonotic bacterium *Rickettsia rickettsii*, the etiological agent of spotted fever in parts of South and Central America (Labruna 2009). The taxonomic status of *A. cajennense* was recently reassessed by Nava et al. (2014). They proposed recognition of six species in the complex in populations distributed across the Americas. This proposition has seen support from other

studies and shows the diversity of *A. cajennense* lineages in the Neotropical (Labruna et al., 2011; Mastropaolo et al., 2011; Beati et al., 2013).

Empirical studies have shown that environmental conditions determine geographic distributions of tick species such that they also shape areas of risk for emergence of tick-borne pathogens (Mather and Howard 1994; Glass et al., 1995; Guerra et al., 2002; Estrada-Peña et al., 2012). Climate is recognized as a major determinant of infectious disease distributions (Peterson 2006) and climatic data have been used to predict geographic distributions of tick species (e.g., Estrada-Peña

* Corresponding author at: Secretaria de Vigilância em Saúde do Ministério da Saúde, Setor de Rádio TV Norte – 701 – Via W5 Norte, Edifício PO 0700, CEP: 70719-040, Brasília, Brazil.
E-mail address: stefanbio@yahoo.com.br (S.V.d. Oliveira).

2008).

Predictive models have been developed using future climate scenarios to assess and understand potential distributional changes of ticks (e.g., Lindgren and Gustafson 2001; Estrada-Peña 2008; Porretta et al., 2013; Estrada-Peña et al., 2015). However, previous studies did not incorporate the implicit uncertainty in the forecasts (Beale and Lennon 2012). In addition, models aiming to predict species distributions in future climates should consider niche conservatism, which has been demonstrated on the local, regional, and global scales, showing evidences that many species have a very limited capacity of adaptation to novel environmental conditions (see Crisp et al., 2009; Soberón and Peterson, 2011).

Previous evaluations have shown that failing to consider niche conservatism may result in predicting survival of tropical vectors even at freezing and boiling temperatures (Owens et al., 2013), generating ecological niche models with lack of biological realism. That is to say, adaptation to novel climates is a slow process (e.g., hundreds of centuries; Peterson 2011), thus, models ignoring niche conservatism assumes that species will evolve fast (~50 years) to be adapted to the current trends of climate warming. An alternative to these artifacts is to assume niche conservatism to avoid model extrapolation under novel climatic conditions (see Anderson 2013; Owens et al., 2013). However, the current practices for modeling vector distributions under future climate conditions fail to consider impacts of model extrapolation in novel climates (e.g., Fischer et al., 2013). Previous models also assumed high dispersal potential of ticks and dramatic range shifts in short terms (i.e., decades). Good practices of vectors modeling under future climates should include estimations of the dispersal potential of species, explorations of several emission scenarios and climate models, ecological niche model transference (i.e., restriction of predictions to environments analogous between calibration and projection areas), uncertainty estimation, and identification of non-analog environmental conditions for more robust conclusions (Soberón and Peterson 2011). As such, the aim of this study is to analyze the potential geographic distribution of two species of ticks of the *A. cajennense* complex (i.e., *A. cajennense* (sensu stricto) (s.s.) and *A. sculptum*), to explore how future climate scenarios by 2050 and 2070 can shape the distribution of these species in Brazil. We assumed non-adaptation of these ticks to climate warming (i.e., niche conservatism) and limited dispersal abilities (see below).

2. Methods

We modeled the distribution of ticks under present-day climate conditions based on a proxy of the potential dispersal of their populations in Brazil, assuming limited dispersal of these populations. Models were then projected to future climate models under different emission scenarios as summarized in a workflow diagram (Fig. 1).

2.1. Dispersal potential

The modeling followed the BAM framework (Peterson et al., 2011), which is a generalization of the factors shaping the geographic distributions of organisms in terms of biotic relationships (B), abiotic constraints (A), and the dispersal potential or movement of species (M). Thus, $A \cap B \cap M$ is the geographic area where the organism of interest occurs (Soberón and Peterson 2005). Models were calibrated based on our hypotheses of dispersal potential, **M**, for the target population of each tick species (Barve et al., 2011). Briefly, to approximate the dispersal potential of tick populations, we used the average geographic distance between a centroid point among populations and all the most distant reports in the study area as described by Poo-Muñoz et al. (2014). Occurrences were restricted to populations of *A. cajennense* (sensu stricto) (s.s.) and *A. sculptum* species in Brazil to resemble the climatic signature of the populations in this region. We estimated a distance of 7.14 geographic degrees for *A. cajennense* s.s. and 7.74 for *A.*

sculptum. These distances were then used to create buffers around occurrences for each population as an approximation of **M**, these areas were then used as model calibration regions (Fig. 2).

2.2. Input data

Occurrence data were obtained from the scientific literature (Nava et al., 2014; Martins et al., 2016) including taxonomic assessments of the *A. cajennense* complex in Brazil, focused on two species, *A. cajennense* s.s. and *A. sculptum*. Occurrence reports were converted to geographic coordinates (WGS 84) in decimal degrees format. In all, after removing duplicates and allowing only one occurrence per grid cell of the environmental layers, 60 confirmed single records of *A. cajennense* s.s. and 122 of *A. sculptum* were used to calibrate the models (Fig. 2).

To characterize environmental conditions across the study region, we explored seven climatic variables that we considered relevant to the species biology in terms of their physiological tolerance: annual mean temperature, mean diurnal temperature range, maximum temperature in the warmest month, minimum temperature in the coldest month, annual precipitation, and precipitation in the wettest and driest months. These variables had been also used in previous studies of the biology of vectors and reservoirs of tropical diseases in Brazil (Gurgel-Gonçalves et al., 2012; Oliveira et al., 2013). We obtained these data layers from WorldClim at approximately 5×5 km spatial resolution (Hijmans et al., 2005), which depicts present-day climate conditions as the interpolation of mean monthly climatic data from meteorological stations over 30–50 (1950–2000) years. Models were calibrated using these variables with original values, however, for visualization of the environmental distribution of the species in present-day climatic conditions, we performed a principal component analysis (PCA) to reduce dimensionality and collinearity of the environmental variables. We estimated convex polyhedrons around available occurrences for each tick species in an environmental space defined by the first three principal components generated from the PCA as these contained 92.43% of the information for *A. cajennense* s.s., and 88.73% of the information for *A. sculptum* from the seven original bioclimatic variables (Supplementary Material S1); both procedures were performed using NicheA software version 3.0 (Qiao et al., 2016a).

Greenhouse gas emissions scenarios proposed by the Special Report of Emission Scenarios of the Intergovernmental Panel on Climate Change (IPCC) were included as representatives of possible future climate conditions (IPCC, 2007; Moss et al., 2008). Specifically, we used the 8.5 representative concentration pathway (RCP 8.5) which incorporates demographic, socioeconomic, and land use patterns to estimate future gas emissions (Moss et al., 2010). RCP 8.5 is a high radiative forcing pathway reaching more than 8.5 W/m^2 by 2100 with higher temperature increases (Riahi et al., 2011). We explored the RCP 8.5 given that previous conservative scenarios of climate (e.g., RCP 2.5) have been proposed as implausible considering recent emissions records (Rahmstorf et al., 2007; Raupach et al., 2007; Manning et al., 2010). Indeed, after a detailed assessment of models considering socioeconomic trends, the RCP 8.5 scenario seems to be the most realistic (Munoz, 2010; Caceres and Nunez, 2011; Noboa et al., 2012). The RCP 8.5 was based on the socio-economic and demographic background, assumptions, and technological approach of the A2 model and is considered and updated and revised quantification of the original IPCC A2 SRES (Riahi et al., 2011), thus, resembling the limited adoptions of green technologies (Snover et al., 2013; Melillo et al., 2014). Models were projected to the RCP 8.5 scenario for 2050 (average for 2041–2060) and 2070 (average for 2061–2080). Because climate models present inherent differences based on the algorithms and assumptions employed (Harris et al., 2014), we explored two different climate models that allowed us to capture variability in forecasts, C-ISM4 and HadGEM2-AO, available at the WorldClim repository (Hijmans et al., 2005).

Download English Version:

<https://daneshyari.com/en/article/5671047>

Download Persian Version:

<https://daneshyari.com/article/5671047>

[Daneshyari.com](https://daneshyari.com)