CellPress

Review

Effects of Climate and Climate Change on Vectors and Vector-Borne Diseases: Ticks Are Different

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There has been considerable debate as to whether global risk from vector-borne diseases will be impacted by climate change. This has focussed on important mosquito-borne diseases that are transmitted by the vectors from infected to uninfected humans. However, this debate has mostly ignored the biological diversity of vectors and vector-borne diseases. Here, we review how climate and climate change may impact those most divergent of arthropod disease vector groups: multivoltine insects and hard-bodied (ixodid) ticks. We contrast features of the life cycles and behaviour of these arthropods, and how weather, climate, and climate change may have very different impacts on the spatiotemporal occurrence and abundance of vectors, and the pathogens they transmit.

Trends

Vector-borne diseases are emerging and re-emerging globally. This has been predicted to be a consequence of climate change, but there is little direct evidence to date.

Predictive models are improving as a result of the integration of modelling methods, more precise climate models, and ongoing validation.

Long-term observational studies needed to monitor climate-change effects are rare, and model-based assessments are mostly being challenged by words rather than by data.

Using remote-sensing and GIS methodologies, we can track environmental conditions that drive vector-borne disease outbreaks in real time, which enables us to improve warnings and risk assessments.

Increasingly sophisticated genomics and bioinformatics analysis tools allow us to better identify and track vectors and vector-borne pathogens, and validate modelling efforts.

Vector-Borne Disease, Climate Change, and the Need for Technical Detail

Since the health implications of global **climate** (see Glossary) change began to be explored, effects on vector-borne diseases have been a focus because of the intrinsic sensitivities of arthropod vector biology and vector-borne pathogen transmission to climate [1]. Early studies raised the hypothesis of significant impacts of climate change on vector-borne disease risks [2,3], but were countered by a range of studies and opinions [4–8]. This debate has focussed on major mosquito-borne diseases (dengue and malaria) that are transmitted from one human to another by the vector and do not involve animal hosts (i.e., they are not zoonoses) and the case was recently made for a more nuanced evaluation of the impacts of climate change on the range of different types of vector-borne disease [9]. Ecological models of vector-borne disease transmission frequently simplify the role of the vector, and this may be eloquent to glean overarching principles of disease transmission [10]. However, for animal and public health end-users, predictions of models of vector-borne diseases (including those predicting impacts of climate change) need spatiotemporal precision to assess current and future disease risks, and for operationally useful early-warning and/or forecasting tools. For these models, understanding the biology of the vectors is critical [11]. Here, we review predictively important differences in the biology of two important groups of vectors of public and animal health significance [dipteran flies, such as mosquitoes and midges, and ixodid (hard-bodied) ticks) in how they may respond to changes in **weather** and climate.

Climate Change as a Driver of Vector-Borne Disease Emergence and/or Re-Emergence

Changes in human populations, landscape, land use, agricultural practices, habitat, and climate are the main drivers of infectious disease emergence or re-emergence [5] (see Outstanding Questions). However, the intrinsic sensitivity of arthropods to weather and climate raises the possibility that, among infectious diseases, those transmitted by arthropods may be the ones

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that are most likely to be impacted by climate change. The anticipated changes to our climate are increasing temperatures, particularly at higher latitudes; changes in precipitation, leaving some areas more drought prone; greater climate variability; and extreme weather events (severe storms, extreme heat events, heavy rainfall events, etc.) [12] (Figure 1). These climatic changes may drive the emergence and re-emergence of vector-borne diseases in several ways: (i) poleward spread of vectors and vector-borne pathogens as climate warms in temperate zones and becomes more suitable for these species. This process may also be accompanied by poleward contraction of the most equatorial limits of these species if temperatures become too hot for them [13]; (ii) greater likelihood and frequency of introduction and endemic establishment of tropical and subtropical vector-borne diseases into currently temperate regions by a combination of (a) rising temperatures in the receiving location, increasing vector and vector-borne pathogen survival; (b) increasing abundance of vectors and vector-borne pathogens in tropical and subtropical source locations; and (c) increasing rates of import of (particularly) tropical and subtropical vector-borne pathogens due to increased climate change-related human migration [14]; (iii) re-emergence of endemic vector-borne diseases associated with increasing

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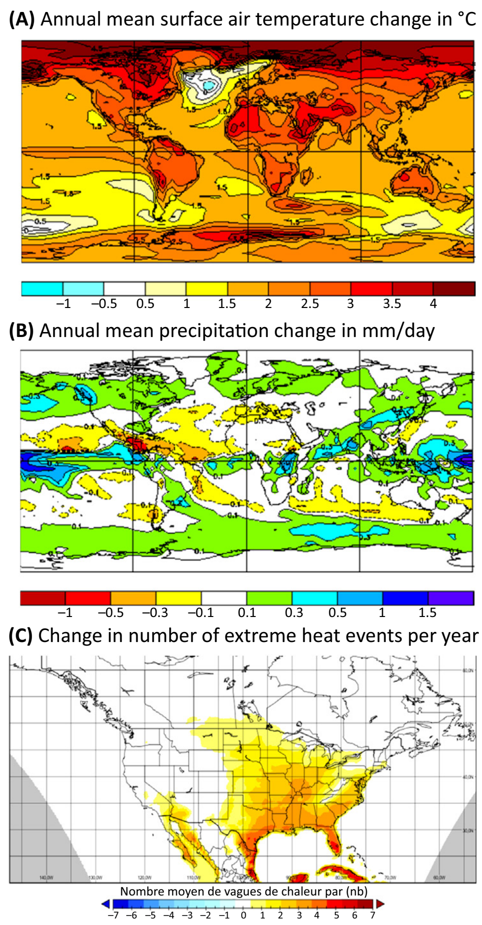

Trends in Parasitology

Figure 1. Projected Climate for 2041–2060. Projected change in (A) mean surface air temperature (°C) and (B) annual mean precipitation rate from 2041 to 2060 relative to 1951–1980 as simulated by the climate model CGCM3/T47 in the IPCC SRES A1B experiment (a five-member climate model ensemble mean using greenhouse gas emissions scenario A1B). (C) Change in the number of extreme heat events in 2041–2070 compared with 1971–2007 using seven regional climate models of the CORDEX experiment using emission scenario RCP8.5. Reproduced from Environment and Climate Change Canada.