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Potential Environmental and Ecological Effects of Global Climate Change on Venomous Terrestrial Species in the Wilderness

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Introduction—Climate change has been scientifically documented, and its effects on wildlife have been prognosticated. We sought to predict the overall impact of climate change on venomous terrestrial species. We hypothesize that given the close relationship between terrestrial venomous species and climate, a changing global environment may result in increased species migration, geographical redistribution, and longer seasons for envenomation, which would have repercussions on human health.

Methods—A retrospective analysis of environmental, ecological, and medical literature was performed with a focus on climate change, toxinology, and future modeling specific to venomous terrestrial creatures. Species included venomous reptiles, snakes, arthropods, spiders, and Hymenoptera (ants and bees). Animals that are vectors of hemorrhagic infectious disease (eg, mosquitos, ticks) were excluded.

Results—Our review of the literature indicates that changes to climatic norms will have a potentially dramatic effect on terrestrial venomous creatures. Empirical evidence demonstrates that geographic distributions of many species have already shifted due to changing climatic conditions. Given that most terrestrial venomous species are ectotherms closely tied to ambient temperature, and that climate change is shifting temperature zones away from the equator, further significant distribution and population changes should be anticipated. For those species able to migrate to match the changing temperatures, new geographical locations may open. For those species with limited distribution capabilities, the rate of climate change may accelerate faster than species can adapt, causing population declines. Specifically, poisonous snakes and spiders will likely maintain their population numbers but will shift their geographic distribution to traditionally temperate zones more often inhabited by humans. Fire ants and Africanized honey bees are expected to have an expanded range distribution due to predicted warming trends. Human encounters with these types of creatures are likely to increase, resulting in potential human morbidity and mortality.

Conclusions—Temperature extremes and changes to climatic norms may have a dramatic effect on venomous terrestrial species. As climate change affects the distribution, populations, and life histories of these organisms, the chance of encounters could be altered, thus affecting human health and the survivability of these creatures.

Keywords: snakes, spiders, Hymenoptera, bees, ants

Introduction

Climate change has been scientifically documented,[1] and its effects on wildlife have been prognosticated. Bites and stings from terrestrial venomous species represent a global public health issue. Venomous snakes alone account for 2.5 million bites per year, with more than 85,000 annual deaths.[2,3] Ants sting 9.3 million people each year. Other Hymenoptera species such as bees account for more than 1 million stings annually. Anaphylaxis secondary to Hymenoptera envenomation affects roughly 3% of the general population.[4] Systemic reactions leading to life-threatening manifestations occur in approximately

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0.4–0.8% of envenomated children and 3% of envenomated adults.[5]

Most terrestrial venomous species are ectoderms and are therefore closely tied to ambient temperature. Wide scientific consensus on the presence of anthropogenic climate change has been established, and its effects on wildlife have been prognosticated in environmental and ecology communities.[1] However, to our knowledge, no study has looked at the global effects of climate change on terrestrial venomous creatures. This review will uniquely focus on climate change and toxinology specific to snakes, spiders, and Hymenoptera species (bees and ants). As more people venture into the wilderness and as climate change affects the distribution, populations, and life histories of many organisms, the chance of encounter could be altered, affecting human health and the survivability of these venomous creatures. Already many forms of media have dramatized the effects climate change may have on human interaction with venomous species.[6,7] With possible shifts in venomous species' regions, limited supply of antivenom may require redistribution to newly populated areas. Additionally, medical practitioners in these new regions may need further education for the timely diagnosis and rapid treatment of envenomation.

Empirical evidence has been accumulating that geographic distributions of many species have already shifted due to changing climatic conditions, particularly away from the equator in polar directions. We sought to review the overall impact of climate change on venomous terrestrial species. We hypothesize that given the close relationship between terrestrial venomous species and climate, a changing global environment may result in terrestrial venomous species migration, geographical redistribution, and longer seasons for envenomation, which may also have repercussions on human health. To this end, we evaluated existing published research that describe and analyze both present and future effects of anthropogenic climate change on individual venomous terrestrial species.

Methods

We conducted a retrospective analysis of environmental, ecological, and medical literature with a focus on climate change, toxinology, and future modeling specific to venomous terrestrial creatures. Species included venomous reptiles, snakes, arthropods, spiders, and Hymenoptera. Animals that are vectors of hemorrhagic infectious disease (eg, mosquitos, ticks) were excluded.

We performed an article review search using the Web of Science core database collection, which provides access to several databases including the Science Citation Index Expanded database (1900–present day), Conference Proceedings Citation Index database (1990–present day), and Book Citation Index database (2005–present day). Additionally, the PubMed NCBI database was used in our search. The keywords used in our search included the following: climate change, anthropogenic climate change, climate, global warming, temperature change, environmental change, envenomation, venomous, distribution, snakes, elapid, viper, rattlesnake, snake bite, ants, fire ants, spiders, recluse, *reclusa*, black widow, arachnid, scorpions, Africanized honey bees, killer bees, and bees. Each keyword was used independently and, when appropriate, in combination with additional keyword(s) to identify relevant articles. The keyword search generated 705 citations, of which 132 were reviewed. From the reviewed material, 64 journal articles, 7 text book references, and 7 governmental/organizational reports were deemed relevant and included in the results section.

We further analyzed multiple ecological niche model studies that project future species distribution. Ecological niche modeling is an area of study in which species distribution algorithms are created by combining present day species geographic occurrences with climate and environmental predictor variables. These algorithms can then be combined with future climate change scenario information, creating future distribution projections.[8]

Results

SNAKES

Venomous snakes exist on every continent (except Antarctica) and in almost every country. Approximately 2.5 million venomous snakebites to humans occur per year and result in 85,000 deaths worldwide, mostly in tropical and subtropical regions of Africa, Asia, and America.[9–11] In the United States specifically, 20% of the 120 indigenous snake species are considered venomous (Figure 1).[12,13]

Snakes, like other reptiles, are ectothermic animals that rely on external heat sources to contribute to many physiological processes. For snakes, increased temperatures have been noted to increase activity time, metabolic rate, digestive function, and activity levels and to extend aboveground time periods.[14] Given the strong correlation between temperature and snake activity, research has evaluated whether a changing climate will lead to changes in distribution. One retrospective study conducted in China noted 9 snake species had significant distribution changes over the last 50 years, largely due to changes of the country's thermal index.[15]

Other researcher groups projected future distribution of venomous snakes using climate change forecasts. Nori