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ORIGINAL RESEARCH

Temporal Dynamics of Phlebotomine Sand Flies Population in Response to Ambient Temperature Variation, Bam, Kerman Province of Iran

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Abstract

BACKGROUND Variations in climate condition may have changed the dynamic of zoonotic cutaneous leishmaniasis (ZCL) and its agents such as sand flies and reservoir in the Bam Kerman the dry region of Iran.

OBJECTIVES In this study we intend to examine the seasonal and interannual dynamics of the phlebotomine mosquito as a function of ambient temperature in Bam, Kerman one of the main leshmaniasis prevalence area in Iran.

METHODS The MODIS land surface temperature product (LST; MODIS/Terra LST/E Monthly L3 Global 0.05Deg CMG [MOD11C3]) and land-based climatic data were used as explanatory variables. Monthly caught mosquitoes in Bam, Kerman, were used as a dependent variable. The temporal associations were first investigated by inspection of scatterplots and single-variable regression analysis. A multivariate linear regression model was developed to reveal the association between ambient temperature and the monthly mosquito abundance at a 95% confidence level ($P < 0.05$).

FINDINGS The findings indicated that the monthly variation of 0-10 cm of soil depth temperature is the main driver of phlebotomine mosquito temporal dynamics. The developed multivariate model also indicated that the ambient temperature variation was responsible for >0.80 of temporal dynamics of phlebotomine mosquitos in Bam.

KEY WORDS phlebotomine mosquito, zoonotic cutaneous leishmaniasis (ZCL), ambient temperature, temporal association

INTRODUCTION

Leishmaniases are among the most important emerging and resurging vector-borne diseases, second only to malaria in terms of the number of affected people.[1] Leishmaniases are endemic in 98 countries. It is estimated that 14 million people are infected worldwide with about two million new cases occurring each year.[2] Among all leishmaniases, cutaneous leishmaniasis (CL) is the most common.[3] There are about

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214,000 cases reported each year and the estimated annual CL incidence ranges from 691,000 to 1.2 million cases (90% in Afghanistan, Algeria, Saudi Arabia, Brazil, Peru, Iran and Sudan).[2] Among the various ecological factors associated to the distribution of particular Lutzomyia species in the New World and Phlebotomus species in the Old World, climate seems to be a critical factor[1] a lot of studies have indicated potential changes in the geographical distribution of certain vector sand flies associated to climate variability.[4-9] Temperature significantly influences arthropod developmental times and other life history events such as survivorship; however, there are few studies documenting the impact of temperature on phlebotomine sand fies.[10] Theodor (1936) described thermal limits for Phlebotomus papatasi (Scopoli) (Diptera: Psychodidae),[11] and recently, Erisoz-Kasap and Alten (2005)[12] determined the degree-day requirements and developmental zero for this species.[10] Ambient temperature significantly affects the developmental rates, survival of preimaginal stages, and the longevity of adult phlebotomine sand flies.[10] The temporal and spatial changes in temperature, precipitation and humidity that are expected to occur under different climate change scenarios will affect the biology and ecology of vectors and intermediate hosts and consequently the risk of disease transmission. The risk increases because, although arthropods can regulate their internal temperature by changing their behaviour, they cannot do so physiologically and are thus critically dependent on climate for their survival and development.[11] Ambient temperature significantly affects the digestion, metabolic processes, and developmental times of sand flies,[12] ambient temperature also affects the developmental rates of the immature stages, survival of pre-imaginal stages, and longevity of the adult phlebotomine sand flies.[13-18] The effects of ambient temperature on the growth rate, size and longevity of mosquitoes under laboratory conditions have been the subject of numerous investigations. The strongest effects of climate on the ZCL cycle may happen at the extremities of the optimal activity temperature range, which for the sand-fly are in the vicinity of 15−18 °C for the low and 32−40 °C for the high end.[19] If ambient temperature reaches the upper values of this range, the transmission could cease completely, seriously reducing the cases of ZCL. Around 30−32 °C, the vectorial capacity is observed to increase significantly due to the shortening of the incubation period, despite a decrease in the vector's survival.[20] In addition to the direct influence of temperature on the biology of vectors and parasites, changing precipitation patterns can also have short- and long-term effects on vector habitats. Increased precipitation has the potential to increase the number and quality of breeding sites for vectors such as mosquitoes, ticks and snails, and the density of vegetation, affecting the availability of resting sites. Disease reservoirs in rodents can increase when favorable shelter and food availability lead to population increases, in turn leading to disease outbreaks. Human settlement patterns also influence disease trends.[11] Although sand files have a significant impact on public health, only a few studies[21,22] have been carried out to measure their susceptibility to specified environmental conditions such as ambient temperature consequently, little is known about the effects of external factors such as temperature on their development and longevity. In the present work, we intend to investigate the temporal association between 3 ambiant temperature factors (land surface temperature, soil 0-10 cm depth temperature, and air temperature) and sand fly population abundance in Bam, the leishmaniases endemic region of Iran, Kerman Province of Iran.

METHODS

Study Area. Kerman is the largest province of Iran, with a population of 2.7 million, as can be seen in Figure 1. The province covers an area of 181,714 km^2 and is located in the southeastern part of the country. The province consists of 23 districts, and cutaneous leishmaniasis has historically been present in Bam districts. In recent years the disease has expanded and spread to new foci throughout the province. The climate is extraordinarily variable, which makes it unique, depending on the relief of the land. The climate in north and northwestern areas is fairly moderate and dry, whereas in the south and southeast the weather is warm and humid. The altitude varies between 300 m above sea level in Manujan district to about 2600 m in Baft.

Data Collection. In this study we used 2 types of data, the environmental data, including remotely sensed data and European Centre for Medium-Range Weather Forecasts data, and the data on monthly abundance of mosquito also were used. The environmental data that were used in this study has been presented in Table 1.

The Mosquito Collection. All night landing catches of mosquitoes were made monthly in the village environment for 4 consecutive nights (2 successive nights in each site) from January to December 2012. There were 2 5-hour collection periods