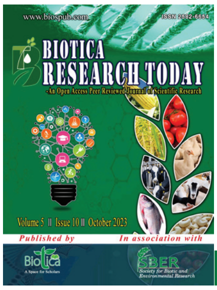

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Climate Change's Influence on Parasitic Diseases

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Abstract

Climate change affects the environment, including temperature, humidity and rainfall patterns with significant impacts on the host-parasite relationship. Changes in temperature and humidity influence vector biology, behaviour and disease transmission. Pathogens and vectors undergo genetic changes due to climate change, affecting their virulence and resistance. A sustainable solution involves social forestry and planting trees to reduce greenhouse gases and regulate climate. Forests also provide shade, regulate temperatures and enhance water retention. Conservation of habitats preserves biodiversity and ecological balance. Addressing climate change requires comprehensive strategies, including mitigation and adaptation. Measures must enhance community and ecosystem resilience and promote sustainable practices in agriculture, energy and transportation. A comprehensive and sustainable approach is essential to tackle this global challenge.

Keywords: Climate change, Control programme, Incidence, Parasitic diseases

Introduction

The effects of global warming on health have received a lot of attention lately (Rossati, 2017). Because of the potential for increased human exposure to diseases carried by vectors which are diseases that can spread from humans to animals, climate change is a serious concern. Climate change-related rising temperatures have the potential to prolong the season during which diseases are spread and make people and animals more vulnerable to different epidemic diseases. A long-term, statistically significant change in temperature, humidity and precipitation patterns over an extended period of time in a specific geographic area is referred to as climate change. According to predictions made by the Intergovernmental Panel on Climate Change (IPCC), the average global temperature has increased by -1.5 to 5.8 °C in the twenty-first century. Additionally, there have been more frequent instances of extreme temperatures. Through changes in their biology, pathogens, vectors, hosts, and their environments may all be indirectly impacted by climate change. Singh *et al.* (2011) conducted a study and review on the effects of climate change on zoonotic diseases in India. Analogously, a great deal of research has been done on the incidence and prevalence of livestock diseases in Great Britain in relation to climate change (Gale *et al.*, 2009). It is clear that epidemics and infectious diseases that impact domestic animals as well as human populations are largely caused by an unstable climate. This increased risk of epidemic diseases is a result of changes in the biology of pathogens, vectors and hosts as well as lengthened seasons of disease transmission. Therefore, preventing the effects on disease dynamics and safeguarding human and animal health, it is imperative to address climate change and stabilize the climate.

Climate Change's Direct Influence on Disease Vectors

Disease vectors, or organisms that can spread diseases from one host to another, are directly impacted by climate change. These impacts carry a risk to the health of humans and animals and have the potential to drastically alter the dynamics of vector-borne disease transmission. Temperature, precipitation and humidity variations brought about by climate change have an impact on the growth, behaviour, reproduction and population dynamics of insects as well as various pathogens, including bacteria and parasitic agents. Because of their physiological limitations, insects are unable to control their body temperature, which can lead to changes in their vector range patterns, increased risk of

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new threats, or even mutations in the species to adapt to specific environments and situations. Because water and humidity are essential for vector breeding, places with standing water and heavy precipitation see an increase in the number of insects hatching quickly. Additionally, temperature-dependent, the incubation period of pathogens within vectors shortens in warmer climates. These are a few of the variables that influence climate change.

1. Distribution and Range

Climate change can alter the geographical distribution and range of disease vectors. As temperature and precipitation patterns change, vectors may expand into new areas previously unsuitable for their survival. This expansion can introduce diseases to new regions and populations that were previously unaffected.

2. Population Dynamics

Climate change can influence the population dynamics of disease vectors. Warmer temperatures can lead to increased breeding rates and shorter life cycles for many vectors, allowing them to reproduce more rapidly and increase their population size. This can lead to higher transmission rates of diseases.

3. Phenology and Seasonality

Changes in climate can disrupt the phenology and seasonality of vectors. Phenology refers to the timing of biological events, such as the emergence of adult mosquitoes or the hatching of vector eggs. Climate change can alter these timings, leading to mismatches between the life cycles of vectors and their host availability. This mismatch can affect disease transmission dynamics.

4. Behavior and Biting Rates

Climate change can impact the behavior and biting rates of disease vectors. Rising temperatures may alter the activity patterns and feeding behaviors of vectors, such as mosquitoes or ticks. Changes in precipitation patterns can also affect their breeding sites and availability of water sources, influencing their abundance and biting rates.

5. Vector Competence

Climate change can influence the vector competence of disease vectors, which refers to their ability to acquire, maintain and transmit pathogens. Variations in temperature, humidity and other meteorological parameters can affect the vector's capacity to harbour and disseminate pathogens, thereby elevating or lowering the rates of transmission.

6. Molecular Mechanisms of the Infection

The potential impact of climate change is the ability of microorganisms to mutate corresponding genes due to adverse effects of the climate. For example, the Venezuelan equine encephalitis virus adapts to its epizootic mosquito vector (*Ochlerotatus taeniorhynchus*) by substituting a single amino acid in its glycoprotein envelope. The RNA virus could readily adapt to shifts in the vector population as a result of climate change. Because of their ability to read genes, RNA viruses have a higher rate of evolution than DNA viruses. The characteristics of numerous biotic and abiotic elements that influence the organism's geographic transmission can be readily altered by virus microbe mutations.

7. Wildlife Ecosystem

Wildlife's habitat and food sources will shift, and their feeding habits will shift due to climate change, which will ultimately alter their social structure and bring in more domestic livestock. The biological invasion of non-indigenous species by their modified variety of recently introduced pathogens is further encouraged by climate change.

Climate Change's Influence on Helminth Parasites

In both temperate and tropical regions, helminth infections have increased as a result of climate change. Changes in humidity and rainfall patterns have an impact on the spread and impact of these bothersome parasites. Animals with the infection lose condition, gain less weight, have abortions, become infertile and occasionally pass away. According to future climate projections, summer temperatures will rise by 2.0 °C to 2.8 °C in a number of locations by 2050. These changing conditions influence the development of helminth larvae, with extreme temperatures being lethal and reducing pasture contamination. Temperature fluctuations also impact parasite populations in livestock, affecting seasonal incidence and overall epidemiology. Relative humidity inside the host is vital for larval survival and development. Long-term climate trends alter parasite distribution, while outbreaks rely on favorable conditions. Climate change and weather variability may also introduce new parasites and affect species composition. Helminth infections were once limited to colder climates but have expanded to warm regions, leading to ruminant animal mortality. Anthelmintic resistance and changing transmission seasons are climate change-related concerns. Effective management, monitoring and new treatments are necessary. Intensifying research and surveillance are crucial to understand climate-helminth interactions, enabling targeted interventions and adaptations. The various ways that the transmission cycle of helminths parasites could be impacted by climate change are outlined below.

Fasciola hepatica

One of the major fluke diseases that affect ruminants is fascioliosis, which is characterized by diarrhea, severe liver fibrosis, weight loss, clay pipe-like appearance of the larvae and occasionally even death. The entire world has seen an increase in the prevalence and incidence of disease as a result of shifting fluke infection patterns and epidemiology. Additionally, there are reports of a rise in the outbreak in sheep and cattle. The construction of more dams and irrigation facilities, which aid in the propagation of snail intermediate hosts, has resulted in an extraordinary rise in *F. hepatica* and *F. gigantic* infections in both temperate and tropical climates. The growth, spread and life cycle completion of snails are favorably facilitated by summer rainfall. A four week extension of the herbage growing season over time is a result of increased humidity, increased rainfall in the winter and autumn and year-round warmer average temperatures, all of which are linked to the long-term changing distribution.

Nematodirus battus

A highly harmful nematode called *N. battus* is present in the small intestine of ruminants, such as cattle, buffalo and mithun. It was previously believed that, in contrast to other cattle parasites, the free-living stages could only grow into infectious larvae following extended exposure to low temperatures (about 0 °C) and a subsequent rise in temperature. The capacity of *N. battus* eggs to hatch without a chilling time along with higher temperature is currently regarded to be a predisposing factor for increased prevalence in domestic animals. Changes in the pattern of infection and associated epidemiology have been documented.

Haemonchus contortus

The primary cause of calves' death is *H. contortus*, an abomasal nematode of ruminants that is normally a parasite of tropical climes. *H. contortus* is highly prevalent and widely distributed, however in sheep and goats, there has been little evidence of an intense epidemic and few clinical cases. Climate change may be to blame for this, as hotter temperatures stimulate larval activity, which raises the risk of infection. In addition to increasing the number of eggs produced later in the year and prolonging the transmission window longer into the autumn, higher autumn temperatures also promote the eaten larvae to develop into disease-inducing adults rather than enter hypobiosis, which is a key driver of the spring increase phenomena. Larvae have been found to be more resistant to desiccation in the warmer, drier summer months. Several non-climatic factors, such as increased anthelmintic resistance and altered animal husbandry practises combined with recurrent exposure to anthelmintic, have also been linked to the increased occurrence of *H. concortus*.

Climate Change's Influence on Fleas and Ticks

Climate change has noticeably affected ticks, such as the brown dog tick *Rhipicephalus sanguineus*. This tick, found in Mediterranean and tropical regions like India, has been sporadically detected in Europe and Asia, including India, where it's been linked to transmitting rickettsial organisms in dogs. *Ixodes ricinus*, commonly known as the castor bean tick, is another prevalent hard tick in Europe that holds significance in domestic livestock farming, thanks to the favorable climatic conditions. Reduced winter days with temperatures below a certain threshold have led to increased Ixodes tick populations, as studies show. These ticks require specific temperature and humidity conditions for their life cycles and their prevalence in Scandinavian countries has risen due to warming temperatures that favor their survival. Climate change holds important implications for ticks and fleas, crucial vectors of diseases. Climate change can influence the interactions between ticks and their hosts. Alterations in the behavior and distribution of host species, such as mammals and birds, can impact tick feeding patterns and their ability to acquire and transmit pathogens. Climate change can also affect the behavior and distribution of wildlife hosts that serve as reservoirs for fleas.

Climate Change's Influence on Mosquitoes

The mosquito life cycle and the transmission of diseases like malaria are significantly influenced by temperature. Mosquito development and survival depend on temperature, with specific minimum and maximum thresholds. Anopheles mosquitoes, responsible for malaria transmission, can't survive beyond a certain temperature threshold. Higher temperatures lead to quicker mosquito life cycles, leaving less time for the Plasmodium parasite to develop in their salivary glands. Temperature limits the transmission of malaria, affecting both the mosquito population and the parasites they carry. In recent years, there have been malaria outbreaks in mountainous regions of Kenya, Uganda and Rwanda. While climate changes in these areas may contribute to the resurgence, it's important to recognize that East Africa experiences varied climate patterns. Other factors, like migration, disruptions in healthcare, changes in vector control and deforestation, also play a role in rising malaria cases. These factors disrupt control efforts, limit healthcare access and alter mosquito habitats and breeding patterns, increasing malaria transmission.

The National Climate Change Action Plan

1. Evaluation of the increased disease burden brought on by climate change.

2. Providing weather and climate data with high resolution so that the regional pattern of disease can be studied.

3. Creation of a state-level, high-resolution health impact model.

4. GIS mapping of the routes leading to medical facilities in regions vulnerable to weather extremes.

5. The ranking of regions according to the degree of vulnerability to the negative effects of climate change and epidemiological data.

6. An ecological investigation of the effects of climate change on air pollutants and pollen, which act as triggers for respiratory disorders like asthma.

7. Research on how disease vectors adapt to changing climate conditions.

8. Better health care facilities should be made available, and public health initiatives like vector control, sanitation, and clean drinking water should be implemented.

Conclusion

Parasitic infections significantly harm livestock production, lowering meat and milk yields. Parasites are often confined to specific climatic conditions, but climate change has increased infection prevalence and intensity. Preparing for these changes and reducing parasitic disease outbreaks globally is vital in a climate-altered world. Forecasting models predict parasite occurrences due to climate change, guiding proactive mitigation measures. Zoonotic diseases, transferred between animals and humans, are also forecasted in response to climate change, emphasizing the need to address climate change for disease prevention. Clinical practitioners can act urgently by implementing management programs and planting emissions-reducing vegetation. Scientific collaboration is essential in developing interventions against climate change's impact on parasitic infections. Applied research is the key to reducing vector-borne disease burdens, bridging the research-policy gap to align with health needs. Health policies on climate adaptation offer opportunities to link research with public health. To combat climate change's impact on parasitic infections, proactive measures, collaboration and applied research integration into public health policies are essential. In the face of a shifting climate, this strategy serves to protect both livestock production and human well-being.

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