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Assessment of the food safety and animal health implications of climate change effects on crops and livestock.

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1. Key Points

- Many of the most important zoonotic pathogens are capable of proliferation outwith animal hosts, in the wider environment. The pathogens are able to interact with alternative hosts and environments, e.g. plants, insect vectors, soils and sediments, from which they can derive nutrients for growth.
- Increases in temperature are likely to favour an increase in the environmental incidence of zoonotic pathogens that have higher optimal growth temperatures than the native soil / water / plant microflora.
- Increased rainfall coincides with the warmer summer months, which provides favourable conditions for persistence and proliferation of zoonotic pathogens in the environment.
- Extreme rainfall events result in flooding and run-off from farmed animal sites, increasing the risk of transmission of zoonotic pathogens in arable crops and water courses.

2. Introduction

The lifecycle of many of the most important food-borne and water-borne human and animal pathogens includes a stage outwith the animal host, where the pathogens must adapt to be able to persist in the wider environment. Broadly speaking, the pathogens can be divided into two groups: those that are able to interact with alternative hosts or environmental habitats and proliferate (e.g. enteric bacteria); and those that require an animal host for proliferation and require vectors to complete their transmission cycle (e.g. virus, parasites). The ability of enteric bacteria to adapt to a wide range of physical, chemical and biological environments is part of the key to their success. For example, although these pathogens undergo maximal rates of proliferation at temperature relevant to animal hosts, their growth range far exceeds these limits, and can extend down to temperatures more relevant to soil and water temperatures (< 8°C). Other adaptations include the ability to use a wide range of carbon sources and to successfully compete against a range of other microbes. Most of the zoonotic pathogens within this class require a relatively high level of water activity, both for motility and growth.

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Climatic change has undoubtedly altered the incidence of zoonotic pathogens in the wider environment. The two aspects that are most relevant to zoonoses are temperature and the increase in rainfall. The average soil temperature in Scotland has increased by more than 1°C in the last four decades and projections predict that the increase will continue. Average rainfall has also increased over the last six decades, with significant increases seen during the summer months (as recorded by the weather station at Invergowrie, Dundee). The combination of increased temperature coupled with greater water availability predicts more beneficial conditions for proliferation of some zoonotic pathogens outside their normal animal hosts, although species-specific differences are apparent with some well adapted to enter a quiescent state at lower temperatures. Furthermore, fluctuations around the average may compound the risk of creating favourable conditions. Finally, extreme rainfall events inevitably lead to water saturation and flooding, with an increased risk of transmission of zoonotic pathogens from farmed animal sites to arable sites and water courses.

3. Research Undertaken

Work at the James Hutton Institute focuses important zoonotic pathogens such as toxigenic *Escherichia coli*, *Salmonella enterica* and *Clostridium* spp. and the livestock pathogen *Mycobacterium avium* subspecies *paratuberculosis* (MAP), to better understand the interactions that occur between the pathogens and different compartments in the environment. The work encompasses arable (mainly horticultural) crops, water courses and soil, with research into the plant-based lifecycle of pathogenic enteric bacteria. We also work on bacteria naturally present in the wider environment in order to gain a better understanding to the basis of genetic adaptations and the likelihood pathogen prevalence in association with plants.

4. Policy Implications

The main impact of the work is on human and animal health. For example, by uncovering aspects of the plant-based life cycle of zoonotic pathogens (e.g. entry into the tissue of plants) and the adaptive processes that underpin these aspects, it is possible to gauge the impact that changing climate conditions will have. Research at JHI has shown that the bacteria can proliferate in the plant tissue and are protected for various stresses, including post-harvest sanitation processes. The presence of an apparently 'endophytic' stage of zoonoses lifecycle means that plants can play an important part in their transmission, either to other animals through grazing or feed, or to human through edible crops.

Water availability is important for bacterial growth and transmission. Research at JHI has found that irrigation of crops through the summer months (which is not necessary during periods of high rainfall) increased the incidence of environmental *E. coli* in soil. Some of the environmental *E. coli* show distinct adaptations to environmental conditions, such as temperature, which facilitates their ability to colonise plants. The significance of these genetic adaptation mechanisms is two-fold: firstly in informing whether similar mechanisms are present in pathogens; and secondly in their potential for genetic transmission, which may result in the emergence of novel pathogens. This was observed recently with the emergence of food-borne pathogen *E. coli* O104:H4 (Germany, 2011) and its altered plant-associated adherence characteristics.

Finally, the potential of extreme rainfall events to transmit pathogens has been demonstrated at JHI from studies of bacterial pathogens with particulate material in the environment. This is particularly relevant for faecal run-off from agricultural land that associates with soil and sediment particles during overland and in-stream flow. For example, the clay composition of soils and sediments affects their survival, and the presence of biofilm on stream sediment can influence whether enteric bacteria bind and settle or are transported further downstream, which in turn influences their dissemination and potential routes of exposure for humans and animals.

5. Further Information

Further details of the work at JHI can be found at the Centre for Human Pathogens in the Environment (HAP-E) http://www.hutton.ac.uk/research/themes/controlling-weeds-pests-and-diseases/hape and from Knowledge Scotland http://www.knowledgescotland.org/briefings.php?id=108

Further information on local weather recording at the JHI is here http://www.hutton.ac.uk/news/weather-records-show-dreich-year-dundee