PART VIII

THE IMPACT OF GLOBAL WARMING ON ANIMAL HEALTH

Somewhat restricted in locale

Introduction

It is accepted that average temperatures will rise over the next 20-30 years and that there will be significant associated changes in rainfall patterns, winds and sea level. The exact nature of climatic shifts cannot be predicted with certainty (Part I) but in Europe the local effects and the consequences of changes in the rest of the world will probably result in significant alterations in land use and in modes of animal production.

Animal management systems create the environment in which causal agents of animal disease are expressed. Climatic change will, therefore, affect animal disease through the influence of both climatic and management factors. The latter is not considered here. The following commentary is based on the expectation that temperatures will rise, rainfall patterns will alter and that there will be consequent changes in animal management systems.

Four aspects of animal health need consideration:

i) microbial infections;
ii) parasitic infections;
iii) zoonotic infections;
iv) nutritional disorders.

New problems may emerge as changes in prevalence, severity and distribution of existing endemic infections and disease and also from the introduction and establishment of exotic disease.

VIII.1 Microbial Infections

Existing temperature differences between southern England and Scotland are greater than the changes predicted for global warming but the disease problems in the two areas are generally similar. However, climatically induced changes in vegetation may alter the abundance and distribution of free-living mammals, thereby facilitating disease transmission. For example, an increase in the badger population could precipitate the spread of bovine tuberculosis to both domestic livestock and free-living deer which are likely to be particularly susceptible (Cheeseman *et al.*, 1989) while a rising rodent population would amplify *Salmonella* and *Leptospira* reservoirs.

In general, the development of milder winters would favour the survival and transmission of enteric, respiratory and other pathogens, increasing the risk and severity of diseases they cause. Housed cattle and pigs could be particularly vulnerable if maintained under conditions of suboptimal ventilation (Dennis, 1986). Conversely, a return to outdoor pig management carries the risk of lungworm re-emerging as a health and production problem. For grazed ruminants, increased stocking rates coupled with milder wetter winters could lead to poaching of pastures (physical damage by hooves) and an increase in infectious foot lameness e.g. ovine footrot. Similarly, stock calving or lambing outside would be more likely to encounter dirty ground conditions favouring an increase in neonatal diseases such as cryptosporidiosis and other forms of infectious scour. The conditions would also favour accumulation of clostridial spores.

In sheep, dental wear and condition are closely tied to pasture management. Any significant change to 'softer' grazing with more lush plant growth would cause excess tooth wear, an increase in related dental problems with an associated need for premature culling of breeding ewes. Any increase in the production of silage and its use for winter feeding of sheep could result in ovine listeriosis becoming more common.

Altered climate may allow the growth of fungi novel to the UK with attendant risks of mycotoxicosis and a possible increase in fungal-induced airway diseases of man and animals such as extrinsic allergic alveolitis (farmer's lung) and chronic obstructive pulmonary disease in horses and farm animals.

VIII.2 Infections Transmitted by Invertebrate Vectors

The predicted climatic changes are likely to have a discernible impact on Britain's most common tick, *Ixodes ricinus.* The essential prerequisite for its survival is the maintenance throughout the year of a humid (>90% saturation) microclimate in the vegetation covering the soil. While markedly drier summers could result in the tick disappearing from some areas the generally higher temperature would alter the pattern of activity, given that the threshold is 7°C. Thus, microbial diseases for which the tick is the vector (e.g. louping ill and tick-borne fever) may become more common.

A number of animal diseases that are vector-borne are currently exotic to Britain, although present in proximal continental Europe. Examples are bluetongue of sheep and African horse sickness in the Iberian peninsula (Mellor *et al.*, 1983). Invertebrate species capable of acting as vectors for the causative viruses are already present in this country and therefore a rise in temperature could facilitate the establishment and persistence of those agents were they to enter the country. Climatic considerations apart, the frequency and ease of long-distance air travel and a 'frontier-free' European Community are inherently conducive to the spread and establishment within Europe, including Britain, of a range of animal and human pathogens most of which are currently exotic to those areas.

VIII.3 Parasitic Infections

All parasites have part of their life cycle outwith the final host and these stages are susceptible to climatic conditions primarily through survival and developmental rates of the organisms. Survival rates in free-living stages are not greatly affected by temperature but most species are susceptible to desiccation. Cold-blooded intermediate hosts are generally more active and fecund in warmer wetter conditions.

Developmental rates in free-living stages and in stages in cold-blooded intermediate hosts are temperature-dependent. Most parasite species require a minimum threshold temperature before development will occur. Some species, for example ticks and parasitic nematodes, are adapted to seek suitable microclimates to survive adverse conditions and are capable of a synchronous response to favourable climatic conditions.

The prevalence of parasitic infections and of parasitoses depends upon complex interactions between:

i) the final host population - its size and age structure;
ii) the parasite populations within and outwith the final host;
iii) where involved, the intermediate host population.

Mathematical models have been developed for many important parasitic diseases and provide a basis for exploring the impact of climatic change on the dynamics of parasite populations. Three simple examples are given below:

a) Parasites With Development Cycles in the Environment.

Free-living stages of gastrointestinal nematodes are dependent on threshold temperatures and adequate moisture for development. Currently there is minimal development of nematode eggs to infective larvae during the period December to March. Temperature is the limiting factor. Any increase in rainfall would have little effect. A 2C° rise in temperature would increase the period when eggs are able to undergo development and extend pasture infectivity into early winter. Larval availability would occur earlier in the spring. For example *Nematodirus battus* requires a temperature in excess of 10°C to hatch and calculations based on the forecasting model of Smith & Thomas (1972) indicate that the peak hatch of larvae would occur 4 to 6 weeks earlier. The implications are uncertain. With current lambing practices the severity of disease may be reduced as the larval peak would be declining by the time lambs are consuming appreciable amounts of grass. However, milder springs would probably encourage adoption of earlier lambing regimes.

The epidemiology of *Haemonchus* would alter as a 2C° rise in temperature would promote a northerly extension of the parasite's geographical distribution. Currently only a small proportion of the parasite population overwinters as free-living larvae on the pasture, the majority surviving in the host as hypobiotic larvae. The requirement for this biological adaptation would be reduced with a warmer winter. *Haemonchus* has a high biotic potential and provided adequate moisture is present the number of parasite generations per year would increase. Strategies of anthelmintic treatment would need to be reviewed particularly as strains of *Haemonchus* resistant to one form of anthelmintic have already been reported.

Increased temperature with lower rainfall in summer would reduce the survival of infective larvae. Resumption of greater rainfall in the autumn may lead to a rapid hatch of eggs and availability of infective larvae resulting in outbreaks of disease.

(b) Parasites With Developmental Cycles in Cold-blooded Intermediate Hosts.

Fasciola hepatica requires the small snail *Lymnaea truncula*ta as intermediate host. A change in temperature will affect two important processes: a) the hatching of eggs on pasture; b) the development of parasitic stages within the snail host. Currently eggs passed by fluke-infected sheep during the summer hatch in 3-4 weeks (Soulsby, 1982) and a rise of 2C° would have little effect. Eggs passed from October to April do not hatch as the average temperature is too low (10°C is the hatching threshold). Increase in temperature would thus extend the period when infective stages are available to the snail. Snail activity will also be increased and the development of the parasites within the snail will occur over an extended period (development within the snail occurs above 10°C) (Soulsby, 1982).

If increased temperature is accompanied by drying out of the snail habitat then snails may undergo aestivation. Development of the parasitic stages within the snail can continue despite the dormancy. Thus a drier warmer summer climate may not greatly affect development within the snail but would delay shedding of cercariae. The return of rain in the autumn would induce a mass release of infective stages.

c) Tick-Transmitted Parasites.

Babesia divergens is a blood parasite of cattle transmitted by the tick vector, *Ixodes ricinus*. Bovine babesiasis is most prevalent in the north and west of Scotland, south-west England and in Ireland, the distribution being determined by the mild, wet climate in these areas. Climatic change accentuating a warm moist micro-environment may be expected to modify the prevalence of bovine babesiasis by extending the distribution of the tick vector and increasing the size of the tick population. Further, the period of the year during which the tick develops would be extended and the rate of development would be increased e.g. oviposition rates of spring-fed female ticks would decrease from 42 days at 10°C to 30 days at 12°C. Nymphal development times would decrease from 104 days at 15°C to 77 days at 17°C. A consequential rise in the rate of disease transmission can be anticipated. The incidence of clinical bovine babesiasis is strongly influenced by temperature, a 2C° rise in temperature can almost double the number of cases of clinical babesiasis.

In summary, parasites will adapt to changing climatic circumstances more rapidly than their hosts, the epidemiology of parasitic disease will alter and there will be need to revise current control strategies.

VIII.4 Zoonotic Infections.

As numerous infections of animals are transmissible to many any change in their prevalence, severity or distribution is likely to lead to comparable changes in human infection. Some of the common zoonoses are listed below:

Foodborne	salmonellosis listeriosis toxoplasmosis tuberculosis brucellosis trichinellosis
Waterborne	cryptosporidiosis giardiasis leptospirosis
Tickborne	encephalitis (louping ill) babesiasis Lyme disease rickettsial disease
Environmental	toxoplasmosis coxiellosis (Q fever) chlamydiosis cryptosporidiosis echinococcosis

Animals are an important, sometimes an essential, component in the medical epidemiology of the infections listed above. Not all of these zoonotic infections may be affected by climatic change, but some almost certainly will be. For example, ticks are likely to thrive in a warmer wetter climate and may extend their range closer to urban areas with increased risks of human cases of Lyme disease, louping ill and even babesiasis. If animal production becomes more dispersed with larger number of smaller free-range units, the risks of infections such as toxoplasmosis, salmonellosis, tuberculosis, brucellosis, trichinellosis will probably increase while the problems of control will become more difficult. Changing patterns of land use, greater leisure time and encouragement of rural tourism and pursuits will increase the probability of human contact with zoonotic infections.

VIII.5 Nutritional Disorders.

The principal effects of global warming on the incidence of nutritional disorders are likely to arise from a lengthening of the growing season for pasture and therefore affect the grazing ruminant animal. A temperature of 4°C represents a threshold for root growth and it might, therefore, be predicted that the onset of pasture growth will be advanced by two weeks (see Table IV.1) by a 1-2C° increase in temperature and its duration may be extended by a similar margin in autumn. Because grass differs from supplementary foods as a source of absorbable nutrients, extension of the grazing season will change nutritional status.

The effects of increased reliance on grass was seen following the imposition of milk quotas when producers fed less supplements to reduce yield: this precipitated an increase in the incidence of metabolic disorders such as hypomagnesaemia in cattle in spring because grass is a poorer source of absorbable magnesium than cereal-based supplements. It is likely that the earlier availability of grass will also increase incidence of hypomagnesaemia and the associated tetany. Other metabolic disorders may be affected if the climate change brings the onset of grass growth closer to the onset of parturition, with its attendant stresses. Extension of the pasture growth seasons in autumn may exacerbate problems of cobalt and selenium deficiencies in lambs. Surveys show that the cobalt (or rather vitamin B_{12}) and selenium status of lambs falls rapidly in autumn until supplementary feeding begins. Extension of the period of reliance on grass might thus increase the prevalence of both deficiencies. While the consequences of such deficiences in terms of retarded growth are often marginal those of diminished disease resistance could be fatal.

Other effects of climatic change on incidence of nutritional disorders in grazing animals could arise from effects on trace element uptake from soil or as soil. Uptake of cobalt and molybdenum by growing plants is affected by soil drainage conditions, with cobalt uptake decreasing and molybdenum uptake increasing as soil moisture rises. Increased rainfall might increase risks of cobalt deficiency and copper deficiency (because copper absorption by grazing animals is readily inhibited by molybdenum). Although pasture growth ceases over winter, sheep and cattle remain dependent on the residue of summer growth in many management systems. As the residue diminishes, increasing amounts of soil are ingested, with beneficial effects on cobalt status (the soil releases cobalt for microbial synthesis of vitamin B_{12} in the rumen) but harmful effects on copper status (through a soil iron x copper antagonism). As winter rainfall increases, so too will the degree of contamination of pasture by soil and hence soil ingestion. Increased problems of 'poaching' may, however, lead to more use of in-wintering management systems. The net effect of all these changes is difficult to predict.

VIII.6 Conclusions.

Assuming that an altered but stable climate is achieved 30-40 years hence, a new set of prevailing animal health problems will be the norm. But the process and rate of change in reaching that situation are likely to create more problems than the change itself. While the process may proceed continuously and imperceptibly to a stable end-point it is more likely that it will be irregular and characterised by periods of enzootic instability. Recent experiences with *Cryptosporidium* in water supplies, *Salmonella* in eggs and *Listeria* in dairy products are possible examples.

Present day responses to the inevitable quantitative and qualitative changes in animal disease that will accompany global climatic distortion will not be applicable by the time the changes occur. Economic factors, energy costs and social attitudes may then demand different priorities. Nevertheless, the basic approach to disease containment, then as now, will be to identify the cause, to define the problem in the host and its environment and to devise rational and affordable control measures through medication, management strategy, vector control or vaccination. Research needs and priorities to meet emerging challenges of animal disease can be framed in the light of these probabilities.

VIII. 7 Research Priorities

i) Surveillance.

For the recognition of changing patterns of indigenous animal health problems and of emerging or exotic disease there is paramount need for a high standard of surveillance that must be supported by refined but robust tests for specific diagnosis and molecular epidemiology. Maintenance of current research to meet those needs is a minimal requirement - the work is too important to be left to the vagaries of 'near market' support.

Surveillance will be required not only at national level as at present but also at farm level by use of sentinel farms equipped to test and record designated flock or herd health parameters. Given requisite investment existing MRI research programmes can develop simple computerised systems for evaluating and identifying enteric parasites by faecal examination, thereby generating data from sentinel farms to aid in advising on changing control strategies.

Accruing national, regional and local surveillance and management data should be accumulated into data bases and used to develop more and better computer models to assist in prediction and planning.

ii) Characterisation of Pathogens.

Irrespective of impending climatic changes, measures for dealing with animal disease are certain to alter, with reduced reliance on chemoprophylaxis of food animals and concomitant increase in biologically based control systems. Progress towards those objectives will require sustained research into the biology and molecular characterisation of animal pathogens including, where relevant, associated work on invertebrate vectors.

iii) Host Responses.

Ultimately, disease is expressed in the animal host. The cellular and molecular mechanisms through which the host is affected by and responds to infection critically determine the outcome of the host-pathogen encounter. Understanding those mechanisms and their inter-host species variations is the key to host-centred control strategies. That understanding can be gained only by fundamental research programmes on processes of infection and immunity that are properly supported in staffing and resources.